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ISSUES IN SPACE LAW AND POLICY

by

Steven A. Padget

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Thesis Advisor: Dan Boger

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Some of the topics discussed are the delimitation and control of space, space debris, and the interpretation of the Anti-Ballistic Missile Treaty. Though they are often seen as issues in space law, it is shown that political considerations and decisions more often determine the outcome or path followed. Further, technical aspects and applications have seemingly usurped any laws which govern use, i.e., what can or cannot be done. Regardless, a commitment to the future use of space is as important as current operations.

This does not imply a need to quickly fill this legal void with well-meaning rules to provide structure. Rather, it is seen that certain laws do need to be created in order to ensure the continued access and use of space will not be interrupted.

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ISSUES IN SPACE LAW AND POLICY

Steven A. Padget
Lieutenant Commander, United States Navy
B.S., University of Southern California, 1985

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Author: Steven A Padget
Steven A. Padget

Approved by: Dan C Boger
Dan C. Boger, Thesis Advisor

Carl R Jones
Carl R. Jones, Second Reader

R Panholzer
R. Panholzer, Chairman
Space Systems Academic Group

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I. INTRODUCTION

The use of space today is largely unregulated. Any laws that may be codified are contained within the text of a few international treaties, or in a limited sense in the national policies of a given country. These treaties, all written over a span of less than a decade (1967 to 1975), were largely the result of the race to space between the United States and the Soviet Union. These treaties have not been modified over the ensuing years, and the fact that they were written at all can be looked upon as being remarkable itself.

This paper outlines the issues that have appeared and shaped the world's approach to activities in space. Some of these issues are poised to shape future operations in space. Therefore, any student studying activities involving the use of space should have a basic understanding of their political and legal foundation. A discussion concerning international treaties and agreements as they pertain to space use is informative. Additionally, by viewing national policies, their evolution, applicability, and their relationship within the international space forum is important. This author believes that the basic understanding gained through the study of these space laws and policies gives any student an appreciation for the regulatory side of space programs. These regulations and laws could prove to be more daunting than any search for a technical solution of a future space problem. Such topics are the delimitation and control of space, space debris, the interpretation of the ABM Treaty, and space warfare.

Chapter II covers the topic of the delimitation and control of space. It traces the establishment of sovereignty over national airspace and builds up to the differing delimitation theories as they were applied to outer space. In some instances, a composite picture is presented as many theories were nearly identical, sometimes differing only in the proposed height limits. In most cases, an intimate depth of discussion was not seen as necessary nor desired in order to present a clear picture of this evolution of man's desire to apply boundaries to everything he can touch. Much of the material was derived from

Congressional hearings, speeches, and published papers dating back to the beginning of the 1950s.

Chapter III details in depth the problem which space debris poses. A detailed presentation of the sources and types of debris, and the uncertainty involved in cataloging the magnitude of the problem was viewed as pivotal in order to gain an understanding of why action is needed on the part of spacefaring nations. Some of the current tracking methods used are discussed, as are the factors affecting debris once it has been created. Finally, and most importantly, a discussion is provided of the various treaties and U.S. governmental policies which detail the current debris control regime and which attempt to provide a means to assign responsibility for the debris created.

Chapter IV briefly discusses several topics that show the formulation of international actions regarding space and reaction to U.S. policies. These topics tend to show a pattern of U.S. behavior concerning the use of space or issues involving space applications.

Almost every topic discussed is followed up with concluding remarks. In many instances, the conclusion contains the author's opinion or beliefs about the issue. Every chapter was written so that it may stand on its own; it is not necessary to read them in the order written. In all cases, just the basic information for the issue is presented so that the reader understands the pertinent facts involved.

II. DELIMITATION AND CONTROL OF SPACE

A. INTRODUCTION

Long before man successfully launched rockets into the upper reaches of the atmosphere, the question of where exactly space "started" had been addressed in academic and legal circles throughout the world. As a matter of course, the additional question of sovereignty in outer space came to be vigorously debated and was thrust to the forefront with the launching of Sputnik by the Soviet Union on 4 October, 1957. Soviet legal experts were quick to point out that no violation of foreign air space had occurred since Sputnik did not pass over other countries; rather, countries passed under Sputnik as the earth rotated [Legal Problems of Space Exploration - A Symposium, 1961].

On 14 May, 1958, in a speech before the Special Senate Committee on Space and Astronautics, Loftus Becker, a legal adviser to the State Department, set the tone the United States would take on the sovereignty of airspace. As he had been advised that the extent of the atmosphere was approximately 10,000 miles above the earth's surface, he stated [Legal Problems of Space Exploration - A Symposium, 1961]:

> ...that it would be perfectly rational for us to maintain that...the sovereignty of the United States extends 10,000 miles from the surface of the earth. At any rate, that type of definition would afford us enough elbow room for discussion.

The question of delimitation and sovereignty of outer space are interrelated questions. They stem from this preoccupation of national decision-makers to fix state boundaries, within which their governments may exercise exclusive rights. This is apparent in the many air and sea legal rules observed by nations around the world today, and is best embodied in Adlai E. Stevenson's statement in 1962 that men are conditioned to think "in terms of states...defined by finite areas expressed in finite measurements...And especially...(men) are conditioned to think in terms of national sovereignties." [White, 1970]

With remarkable foresight, Henry Cabot Lodge, in a statement to the United Nations General Assembly on 13 November, 1958 regarding the legal aspects of outer space, put forth the following idea [White, 1970]:

> Nations have had so far only the most limited and tentative experience with space exploration, and there is very little knowledge of it. We need the information which comes from experience in order to get some idea of the practical problems man's entry into space will create. Such knowledge is a prerequisite to definitive legal rules for outer space. As this knowledge is acquired, the law of outer space will develop gradually and as actual situations and concrete problems call for legal answers.

Similarly, it is important to view some of the early attempts to define air space, as these early arguments and agreements are the genesis of man's search to define the limits of outer space.

B. THE EARLY 1900s

From the advent of balloon flight in the late 1700s to the first flight of the aeroplane in 1903, governments had looked at ways to control the air space over their countries through the use of regulations, and by the application of force if necessary. The chief threat posed by such "illegal" overflights were acts of espionage, namely photoreconnaisance. During this time there were largely two major theories regarding the boundaries of airspace. The first was the "freedom of the air" and the second was one of exclusive sovereignty.

1. Freedom of the Air

In 1906, the French delegate to the Institute of International Law meeting in Ghent put forth a theory (first proposed in 1902) that the air space should be open to aircraft of all nations, with the restriction that individual states could take suitable measures in the interest of their own security. This theory actually divided the air into <u>three zones</u>: a *lower zone*, up to 330 meters (later modified to 1500 meters) which could be used for the construction of buildings and where flight would be prohibited to other states; the *zone above* 5000 meters which could not be reached by aircraft; and the *zone in-between* would be open to free

flight. It is interesting to note that the height of the Eiffel Tower is approximately 330 meters. [Space Law - A Symposium, 1958]

Later, at an Institute meeting in Madrid in 1911, this freedom of the air principle was adopted. The Institute stated that [Space Law - A Symposium, 1958]

> ...international aerial circulation is free, saving the right of subjacent states to take certain measures, to be determined, to insure their own security and that of the persons and property of their inhabitants.

Meanwhile, many other governments took a vastly different view upon the air space over their property.

2. Absolute Sovereignty

The absolute sovereignty theory held that the air space over the territory and territorial waters was the sovereign right of the subjacent nation and could not be restricted by any easement-like "right of transit flight" [Legal Problems of Space Exploration - A Symposium, 1961].

In 1911, in reaction to a growing concern of control of the air space over their nation, the British Parliament passed the Aerial Navigation Act which allowed the Secretary of State to prohibit flight over such areas as may be prescribed in the order. This was done under the auspices of protecting the public, and was really enacted in order to prevent any accident during the Coronation procession that year.

This act was followed up with the Act of 1913, a clear assertion of national sovereignty in air space. It allowed the Secretary of State to prohibit aerial flight for a number of purposes; the chief purpose was for the "defense or safety of the realm" and that the prescribed areas "may include the whole or any part of the coastline of the United Kingdom and the territorial waters adjacent thereto". Aircraft which failed to comply could be fired upon. [Johnson, 1965]

Similarly, in November of 1912, the Russian Cabinet had authorized the Minister of War to prohibit aerial flight over the western borders of Russia. Again, armed force was authorized to enforce this restriction.

Accordingly, in order to resolve these differing opinions on air space sovereignty, the International Law Association met in Madrid in 1913 and put forth the following resolutions [Space Law - A Symposium, 1958]:

> 1. It is the right of every State to enact such prohibitions, restrictions, and regulations as it may think proper in regard to the passage of aircraft through the air space above its territories and territorial waters.
>
> 2. Subject to this right of subjacent States, liberty of passage of aircraft ought to be accorded freely to the aircraft of every nation.

It should be noted that both of the Madrid meetings were not official diplomatic conferences. Additionally, no U.S. representative participated in any of the discussions, though U.S. citizens were members of both organizations.

C. THE PARIS CONVENTION OF 1919

During World War I, countries declared their air boundaries closed, and any belligerent aircraft caught flying over neutral territory were forced to land and the crews interned. World War I was to prove the strategic importance of aircraft; there was now little question that the national security of a country was greatly dependent upon the domination of its air space. This importance was best exemplified by Great Britain's entrance into the war in 1914 with just 12 aircraft. By November 1918, it had expanded to 22,000 aircraft with some able to carry 5-ton bombs more than two hundred miles. The speed and mobility of that day's aircraft forever doomed the theory of freedom of the air; national security and defense dominated government opinions.

Thus, from the deliberations of the Paris Peace Conference, an Allied aeronautical commission was organized in order to draft a set of aerial navigation rules. From this Convention came the Regulation of Aerial Navigation, signed on 13 October, 1919. Article 1 declared that "every Power has the complete and exclusive sovereignty over the air space above its territory". Article 2 of the Regulation also provided for the "freedom of innocent passage above its territory to the aircraft of the other contracting States..." and Article 15 allowed that "the establishment of international airways shall be subject to the consent of

the States flown over". The Paris Convention was ratified or adhered to by thirty-four nations. It was signed on behalf of the United States on 31 May, 1920 but was never ratified by the U.S. government. [Space Law - A Symposium, 1958] Sovereignty of a State's airspace was now an accepted standard in international law.

D. THE CHICAGO CONVENTION OF 1944

Before the end of World War II, it was apparent to governments around the world that a better foundation for the establishment of a set of civil aviation standards would be needed after the war. The performance which aircraft could now achieve easily proved the need for a more specific set of international rules.

Therefore, in 1944, fifty-two governments attended a conference in Chicago in order to achieve a world-wide consensus for a post-war order in civil aviation transportation; the numerous regional bilateral and multilateral agreements made between the two World Wars would no longer suffice in this new age. In doing so, the Convention clearly recognized the future economic potential that civil aviation would play in post-war world affairs. Many world leaders realized that a failure in this endeavor could burden many countries, especially those without seacoasts.

The work of this Convention resulted in the creation of the Constitution of the International Civil Aviation Organization (ICAO) which came into force on 4 April, 1947. Like the 1919 Convention before it, Article 1 of the 1944 Convention reaffirmed the principle that "the contracting States recognize that every State has complete and exclusive sovereignty of the airspace above its territory." Territory as defined includes the adjacent land and territorial waters. As an additional point, Article 3 states "The Convention shall be applicable only to civil <u>aircraft</u>..." [Johnson, 1965].

The Convention also defined five so-called *freedoms of the air*. The first two freedoms are set forth in the International Air Services Transit Agreement: the privilege of flying across a country non-stop; and of flying across with a stop for technical purposes only. These are also known as *transit rights*. The other three freedoms are known as

traffic rights because they refer to passengers, mail, and cargo carried on commercial flights; international consensus of these traffic rights was never reached due to the numerous and conflicting economic implications involved. Currently, these traffic rights are generally concluded through bilateral and multilateral international agreements. Today, most nations of the world have ratified or adhere to this Convention.

E. OUTER SPACE

As the 1950s approached, a new problem was developing which would create even more debate than was seen at the two previous Conventions. The question now was not one of air space sovereignty, but of how high does this sovereignty extend. Some claimed it extended *ad infinitum*, but this was clearly viewed as being unrealistic.

Therefore, in order to define outer space, an exact definition of the term "air space" was needed. To arrive at such a definition, many jurists turned to the task of defining where air space stopped. By doing so, it would follow that the start of outer space would then be self-evident.

1. Spatial Approach

a. Scientific Application

The literal interpretation of "air space" or "atmospheric space" is that portion of space which is right above the earth and is filled with air. However, where this air ceases to be of any real or measurable importance is the central issue in the determination of an upper boundary. Space up to an altitude of approximately 50 km contains about 99.9% of the whole atmospheric substance [Legal Problems of Space Exploration - A Symposium, 1961]. The general consensus among many authors of the 1950-1960s concerning the various atmospheric layers consisted of the following:

troposphere:	sea level to approximately 10 km (6 miles)
stratosphere:	approximately 10 km - 40 km
ionosphere:	approximately 40 km - 375 km
exosphere:	approximately 375 km - 20,000 km or more.

Though this list is not all inclusive, the general idea of breaking down the atmosphere into component parts is made. Of these layers, some believe the "atmosphere" consists of the

troposphere and the stratosphere, while many scientists consider the ionosphere to be the upper boundary of the atmosphere. In addition, there are many other factors one could consider in order to determine this upper boundary, among them being the height at which meteors become luminous (~300 km) and the height of the observable rays of the aurora borealis (~1100 km). [Matte, 1969]

b. Physiological Effects

Another way to view the spatial approach is to simply look at the impact the environment exhibits upon the human body. Specifically, what are the critical altitude(s) where the absence of oxygen will adversely impact the functional ability of a human?

In general, lack of oxygen begins at 10,000 ft. (3,000 m). At approximately 18,000 ft. (5,500 m), the air pressure is half that at sea level. Loss of consciousness can occur between 25,000 - 30,000 ft. (7,500 - 9,000 m). However, a man breathing pure oxygen (non-pressurized) will continue to function normally until about 34,000 ft. (10,000 m); at this altitude, the oxygen pressure in the bloodstream is the same as that at sea level. At 52,000 ft. (15,800 m), a man will lose consciousness in approximately 15 seconds as the partial pressure of oxygen in his lungs is zero; the lungs contain only water vapor and carbon dioxide. At 63,000 ft. (19,200 m), the atmospheric pressure equals the vapor pressure of water at body temperature (37°C). Water vapor is now the only gas present in the lungs, causing the blood to boil. [Encyclopedia Britannica, 1974]

Therefore, because these widely disparate data points and views all lead to different opinions, it was apparent that any attempt to define the upper boundary of air space through scientific discussion and application would not lead to an international agreement.

2. Functional Approach

The inability to fix the altitude limits of national sovereignty based on scientific or technical criteria was proof to many that any division should be based upon the activity

involved, i.e., it would be adequate to strictly distinguish between flights of space and aircraft [Zhukov, 1984].

a. Navigable Airspace

This particular *functional approach* was based upon the belief that the division should be viewed as that airspace which was navigable and that which was not. It seemed to be the perfect way to differentiate between air space and outer space. Relying upon such a premise, however, required a definition of *navigable air space.*

Consequently, it seemed logical to look to established law in order to derive some legitimacy needed for such a discussion. Of course, the law looked at was the 1944 Chicago Convention. As stated previously, Article 1 of the Convention recognized the complete and exclusive sovereignty of the air space above a State's territory. But the Chicago Convention never defines the term "air space" or any altitude limit of a State's sovereignty, nor has it ever been defined elsewhere in international law.

It was generally believed that the delimitation argument could end if the definition agreed with an opinion such as the one declared by the International Law Association in 1958; this opinion stated that "the term airspace used in Article 1 of the Chicago Convention of 7 December, 1944, is in its plain meaning synonymous with atmospheric airspace." [Matte, 1969]

This lack of an explicit definition of air space was an insurmountable hurdle, one that would render the Convention useless in the establishment of an upper boundary. Problems of this nature would be solved in the future by the Vienna Convention on the Law of Treaties, which entered into force on 27 January, 1980. Article 31 of this document states in part that "A treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in light of its object and purpose." [Vienna Convention, 1980]

However, it was to be the close relationship between aircraft and air space from which the legitimacy of this functional approach evolved.

Territorial air space, as defined in the 1944 Convention, would be called navigable air space. Further, this air space extended upward to such heights where aircraft could be operated using only gaseous air for aerodynamic lift to maintain flight. [Matte, 1969] The basis for this was Annex 7 to the Chicago Convention which provides for the definition of an aircraft as "Any machine that can derive support in the atmosphere from the reactions of the air" [Matte, 1969]. This approach seemed to be upheld in principle by a statement made by the Director of the Legal Department of the United Nations in 1958. He stated that "there is reasonably broad consensus of expert opinion that the terrestrial air space, as mentioned in the Paris and Chicago Conventions, does not extend outside the limits of the atmosphere contributing to the lift or support of aircraft." [Matte, 1969]

It is interesting to note that the Soviet view for much of the 1960s through at least the mid-1980s held that this functional approach failed to take into account any prospect of further significant scientific and technical advances in air and space flying machines. This showed their belief of a natural progression that would result in the blurring between aeronautics and astronautics. [Zhukov, 1969, 1984]

In view of the above, on 4 October, 1960, a Soviet-American agreement was reached at the International Aeronautical Federation. It qualified as "*spacecraft*" any craft exceeding 62 miles (100km) in altitude [Matte, 1969].

b. Non-navigable Airspace

As time progressed, it appeared that many jurists agreed that any altitudinal limit of a State's sovereignty should be established higher than the ceiling of normal aircraft flight [Zhukov, 1969]. This perspective can be seen if the delimitation problem is approached by looking at the flight results of the United States' X-15.

The X-15 was a rocket-driven winged machine which used aerodynamic lift when available and used a different system of controls when aerodynamic lift was lost. As such, it was sort of a hybrid aircraft-spacecraft. By 1963 it had attained an altitude of 47 miles (70 km) and would ultimately reach 60 miles. Since the ceiling of usual flights of

aircraft was approximately 25 miles (40km), many felt that the air space should possibly extend to the point where any aerodynamic lift was available, or possibly even to the point where the atmosphere was sufficiently dense to prevent a satellite's orbit. This led to the suggestion that 50 miles (80 km) would be a practical boundary for the following reasons [Matte, 1969]:

> 1. It is well above the altitude we can generate aerodynamic lift to control a vehicle.
>
> 2. Even at speeds approaching satellite velocities, much of a vehicle's capabilities are received from dynamic lift compared to aerodynamic lift.
>
> 3. At 50 miles altitude the density is such a small fraction of 1 percent of the atmosphere that it should be acceptable to consider that all useful qualities of the atmosphere are below that level.

One could now rightfully claim that the path toward a functional approach for space delimitation appears to have again turned into an arbitrary and controversial road, away from classifying flight based upon the type of activity involved. Perhaps the functional approach in its purist form already exists as embodied in Article I of the 1967 Outer Space Treaty: "Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind..." Moreover, it would appear that any attempt to define where space begins will simply be based upon the physical and scientific limitations imposed by present technology.

3. Zone Approach

a. Law of the Sea

The arguments for *freedom of the seas* date back to the Roman era. This idea also saw foundation in 1580 when Queen Elizabeth rejected a Spanish protest of Sir Francis Drake's "violation" of Spanish sovereignty by having sailed in the Pacific without Spanish permission. Queen Elizabeth declared that vessels of all nations were entitled to use the ocean. [Space Law - A Symposium, 1958]

However, total freedom on the seas did not come without qualification. Most nations did believe in some sort of buffer area along their coasts as a measure to blunt

possible foreign intrusion. Further, from the time George Washington was President until about 1960, the United States had advocated the *"three-mile rule"* as the limit of a State's sovereignty of territorial waters. The basis of this "three-mile" limit was predicated upon an age old rule (c. 1645) of what was considered to be the utmost range of a cannon ball. This customary observance over time became accepted by most nations of the world as international law.

By the early 1900s, many parallels had been drawn between the law of the sea and that of the air space. Since sovereignty of the airspace had been acknowledged internationally by the 1919 Convention, many argued for the analogous application of sea law to provide the foundation of air space law. Chiefly, since the time-honored *right of innocent passage* of a ship through territorial waters was uncontested in international law, proponents believed a foreign aircraft should receive similar rights through national airspace.

In 1958 the United Nations Convention on the Territorial Sea, commonly known as the "Law of the Sea", formally recognized the right of innocent passage of ships through territorial waters. Passage was deemed innocent as long as "it is not prejudiced to the peace, good order, or security of the coastal State". It provided for the protection of a State's security in the ability of that State to suspend innocent passage after due publication and without discrimination among foreign ships [Space Law - A Symposium, 1958]. However, it wasn't until 1965 that the generally recognized three-mile claim was supplanted by a *twelve-mile claim* among a majority of the Law of the Sea conferees; this twelve-mile claim was finally established as international law in December, 1982 [Robertson, 1992].

Most notable in the 1958 Law of the Sea Convention was the recognition and universal acceptance of the establishment of a *contiguous zone* extending not more than 12 nm from the baseline from which the breadth of the territorial sea was measured [Robertson, 1992]. Inside this contiguous zone, a coastal State could exercise the control

necessary to prevent infringement of its fiscal, immigration, customs, or sanitary regulations within its territory or territorial waters. This contiguous zone, now firmly established in international law, was extended to twenty-four nm from a State's baseline by the 1982 Law of the Sea Convention. Further, it seemed to help give rise to an approach for airspace division borrowing upon the same principle.

b. Contiguous Zone

In the early 1960s, a prominent United States air law professor put forth a theory of zones in order to define airspace. The theory had three zones: (1) the airspace immediately over a State, within which the State would exercise complete and exclusive sovereignty; (2) an intermediate area within which free passage should be granted for peaceful purposes; and (3) an unlimited outer area of free space. [Matte, 1969]

This theory had two important considerations:

(1) That the limit of national sovereignty, complete and exclusive, should be reasonably low, in order to facilitate the exploration of space;

(2) That the subjacent States would have a legitimate interest in exercising certain control powers in the contiguous zone, for reasons of conservation. [Space Law - A Symposium, 1958]

In the first zone, or territorial air space, there would not be the right of innocent passage as found in maritime law. Further defined, this zone would consist of that air space which was navigable. The second zone would consist of the non-navigable air space, similar to the contiguous zone in maritime law. [Space Law - A Symposium, 1958]

A zone theory looked promising if the definition of "air space" was internationally accepted as that air space which is navigable by aircraft. Additionally, there was much disagreement over how many zones there should be. Some went so far as to propose four, while a majority believed there should be two, with the contiguous zone being discarded. The two zone theory essentially recognized State sovereignty in the

navigable air space, since it was argued that the basis for this concept was already rooted in the 1944 Convention. Further, it gave free status to the zone beyond, or space.

4. Other Theories

Many other theories have attempted to define an appropriate boundary between air space and outer space without taking on the burden of defining either. A few are discussed below.

a. Kepler's Laws

A scientist named von Karman expressed an idea which stated a definite altitude to describe the primary jurisdictional line between air space and outer space. This altitude defined the limit at which aerodynamic displacement ceases and the force of the Kepler laws begin. This division was called the *Karman line* and was originally set at 85 km and was later changed to 100 km in the early 1960s. This change was chiefly brought about because of the experimental flight results of the United State's X-15 aircraft. [Matte, 1969]

Even the proponents of the Karman line saw that this theoretical limit line of air space navigation could be significantly changed given the development of improved cooling techniques and more heat resistant materials and then applied to aircraft design.

b. Earth's Gravity

One author in 1953 thought the best way to scientifically describe the boundary between air and space was to set it "where the mathematical value of the field of the earth's gravitation is nil, or in other words "where weight ceases its manifestations" [Matte, 1969]. Still others, in 1955, believed in this same theory but really for functional purposes. They reasoned that the ever increasing altitudes attained by aircraft necessitated the need to fix in the air where the national sovereignty of States could not be violated. Therefore, they stated that using "the criteria based on the strength of the earth's gravity, as an indication of sovereignty, is the most objective, the most rational and the surest" [Matte, 1969].

However, these gravitational theories are imprecise at best as they cannot account for the variance of the field due to the earth's oblateness, rotational effects, etc. Therefore, because of this burden of defining exactly where gravity ceases and the impractical altitudes which it implies renders this theory essentially useless.

c. Orbit

This theory relates to the lowest point of a satellite's orbit, or perigee. Simply stated, the theoretical line of demarcation of a State's sovereignty would lie at the perigee of the lowest flying satellite of any State. Basing outer space delimitation upon such an altitude seemed promising to many. This theory came to be favored by Soviet jurists.

The premise for this theory was simple. By the late 1960s, hundreds of satellites and spacecraft had been launched into orbit. Generally, the perigee of most had approached no closer than 160 km. Further, these flights did not evoke any protests from the States over whose territories they passed. However, the Soviets at this time believed it was still too early to conclude that an international convention was being formed or had been formed on basing an altitude limit consistent with perigee. They saw that the absence of protests from any State against such satellite launchings and orbits could be interpreted as implied consent to the principle of freedom of outer space for peaceful activities in general, but not as recognition of the freedom of access to outer space at a certain altitude. However, this Soviet viewpoint was to gradually change. [Zhukov, 1969]

In 1979, the Soviet delegation to the 22nd session of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) submitted a working paper on the delimitation of air space and outer space. It contained the following points [Zhukov, 1984]:

1. The region above 100/110 km altitude from the sea level of the Earth is outer space.

2. The boundary between air space and outer space shall be subject to agreement among States and shall subsequently be established by a treaty at an altitude not exceeding 100/110 km above sea level.

> 3. Space objects of States shall retain the right to fly over the territory of other States at an altitude lower than 100 (110) km above sea level for the purpose of reaching orbit or returning to Earth in the territory of the launching State.

This Soviet delimitation proposal was highly flexible in its content, as it did not rule out the delimitation of outer space below 110 km; a statement made by the United States representative to the Committee pointed out that in 1974 a U.S. satellite had a 96 km perigee.

It is interesting to note that in 1976, a working paper entitled "Study on the Altitudes of Artificial Earth Satellites" was prepared by the United Nations Committee on Space Research (COSPAR) [Zhukov, 1984]. This paper gave detailed characteristics of low perigee satellites and estimated that the lowest altitude at which a satellite could survive without burning in the atmosphere was 90 km. Further, a Czech scientist working as the director for the United Nations Secretariat space section stated the following [Zhukov, 1984]:

> The criterion of the lowest perigees of Earth satellites has the advantage that it is based primarily on physical concepts, which are invariable. It depends on technological progress to a very slight degree. In principle it would be possible to construct a special-purpose artificial satellite which would survive below 90 km or at any height, for that matter. There would however, be no gain in any application of such a satellite and its cost would be out of proportion because an extreme mass-to area ratio can be achieved only by using heavy materials such as lead, gold, uranium, or platinum in large quantities.

Throughout the 1970s, the idea of using this 90 km or 100/110 km altitude as the division air and space was viewed as the most realistic method for sovereignty limitation. The United States, however, still believes that the issue should be solved on a functional basis.

To date, there has been no agreement reached and little further effort in obtaining an international agreement based upon the above principles.

F. CONCLUSION

In spite of the considerable time and effort spent to determine a space boundary, it still remains elusive. It may be akin to the search for Xanadu. But perhaps those who

believe the search is meaningless are correct. It is probable that this quest has been nothing more than an attempt to keep security of the State intact. However, any State can be threatened from much higher altitudes than the 50, 80 or even 100 km proposed delimitation altitudes. Further, even the establishment of such a boundary for the purposes of State sovereignty would not prohibit another State the right to take steps to safeguard its security against hostile actions above that limit. This right to maintain and defend a State's interests in space exists in accordance with Articles III and IX of the Outer Space Treaty [Zhukov, 1984].

It is difficult to speak of any physical border between the air space of the earth from outer space. A similar yet stronger argument can be made of the boundary between the territorial seas and the high seas. Yet the impossibility of any State attaining the "high ground" from any part of the sea immediately discounts any serious consideration of the perceived parallels between the Law of the Sea and its applicability to space delimitation and sovereignty.

Perhaps this issue will remain unresolved as long as space continues to be viewed as a military conquest or an economic contest.

III. SPACE DEBRIS

A. INTRODUCTION

There is one aspect in which space can be likened to the sea. This is evident in man's practice of discarding refuse into the environment in which he operates. The sheer vastness of each environment initially elicited no recognition of the potential for future problems; the easiest course was to simply ignore the issue. However, today the effects from such actions on the seas is well known, documented, and studied. Conversely, the effects from space debris are much less known, though good documentation and an improving modeling capability has increased our understanding of the problem and the predicted growth rate of the debris population.

At this time, it can be said that much of the risk space debris poses is a *low-probability, high-consequence event*. In other words, a major debris impact is extremely unlikely presently, but its occurrence would have an enormous consequence if it did. Additionally, it is postulated that an unchecked growth of space debris will result in a "*runaway*" series of spacecraft impacts. This result could lead to the abandonment of certain orbital altitudes due to high impact probabilities, and could make certain functions too expensive, or even physically impossible because of the amount of shielding required.

B. TYPES OF DEBRIS

1. Natural

Observation has shown that there is a total of 200 kg of meteoroid mass within 2000 km of the Earth's surface at any given time; this region contains the most often used orbits for spacecraft [The National Science and Technology Council, 1995]. These meteoroids are the product of fragmentation and disintegration of comets and asteroids that orbit the sun (heliocentric orbits) and pass through the Earth's orbital space. They typically range in size from a fraction of a micron to millimeters in diameter [International Academy of Astronautics, 1993].

Historically, this "steady rain", or flux, of meteoroids comprised the original design environment for spacecraft. Numerous measurements were conducted in the 1960s to determine this meteoroid flux. Results showed the probability that $1m^2$ of spacecraft surface in low Earth orbit (LEO) would be struck by a 1 cm diameter meteoroid during a year in space is approximately 1:1,000,000 [National Research Council, 1995].

The flux of meteoroids upon spacecraft in Earth orbit and upon the Earth itself is often used as a "threshold" when discussing the flux of the orbital debris environment. Most of this meteoroid mass is in objects about 0.01 cm in diameter with an average density of $0.5g/cm^3$. Figure 1 shows the estimated meteoroid flux at 500 km altitude. The flux will vary with altitude, dependent upon the Earth's shielding and gravity. Typical meteoroid velocities will vary from 15 to 20 km/s, with an average of 17 km/s. [National Research Council, 1995]

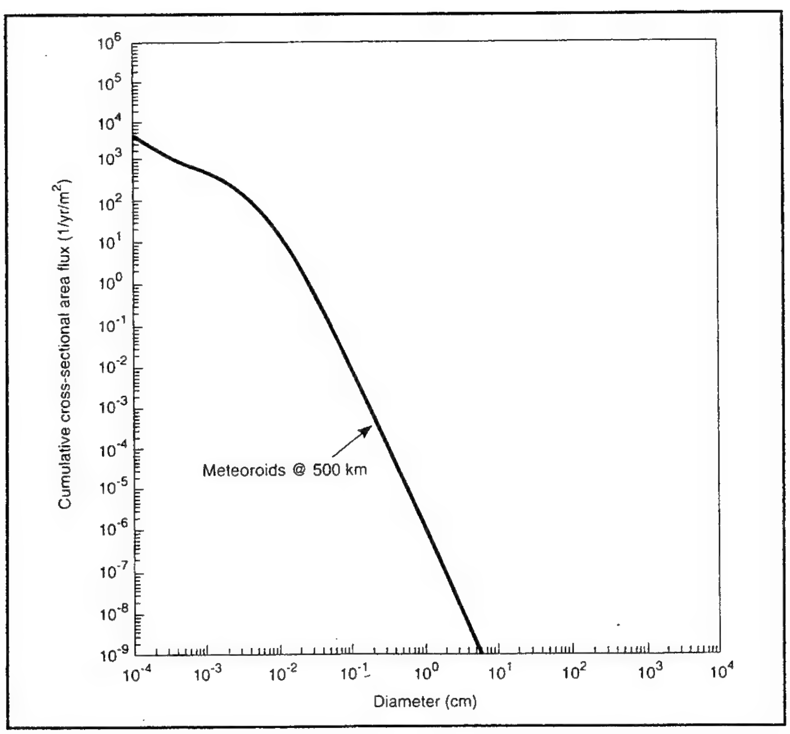

Figure 1. Meteoroid environment at 500 km altitude. [From National Research Council, 1995]

2. Orbital

Since 1957, more than 4500 spacecraft have been launched into space. Today, almost 2200 remain in orbit of which only approximately 450 are still functional. The rest are non-functional spacecraft and are considered debris, yet they comprise only a fraction of the total of Earth-orbiting debris [National Research Council, 1995]. This man-made debris is estimated to have a combined mass of 3,000,000 kg within 2000 km of Earth [The National Science and Technology Council, 1995]. The average relative velocity of these objects is 10 km/s (~22,000 mph) with maximum values of 14 km/s.

The U.S. Space Surveillance Network (SSN) has cataloged 23,000 space objects since 1957, and almost one third remain in orbit today [National Research Council, 1995]. It is important to note that this number represents only those which currently can be sensed from Earth; the actual number of pieces of orbital debris is estimated to be in the trillions. The objects that can be detected are classified into one of the five categories shown in Figure 2.

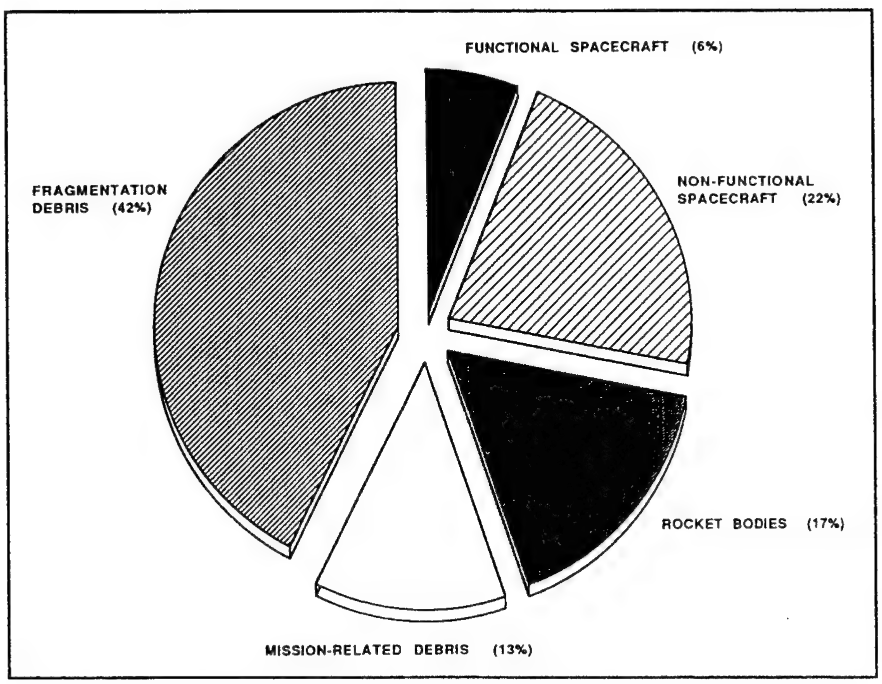

Figure 2. Catalogued space objects, 1994. [From National Research Council, 1995]

a. Rocket Bodies

Spacecraft inserted into LEO generally leave only one expended rocket body in orbit. Spacecraft traveling to geosynchronous orbit (GEO) usually leave two rocket bodies in various intermediate orbits; one will be in a highly elliptical geosynchronous transfer orbit (GTO), and the other will be used for final orbit insertion before being discarded. These rocket bodies pose a danger to present and future functional spacecraft whose orbits intersect these transfer and insertion orbits. Some payloads, however, are designed to remain attached to their orbital insertion stage and therefore greatly reduce the hazard of future collision.

Undoubtedly the greatest hazard these rocket bodies represent while in orbit is contained within them; large amounts of unspent fuel and other energy sources could potentially cause an explosion years after mission accomplishment. Figure 3 shows the typical detectable debris produced by a Proton launch to GEO.

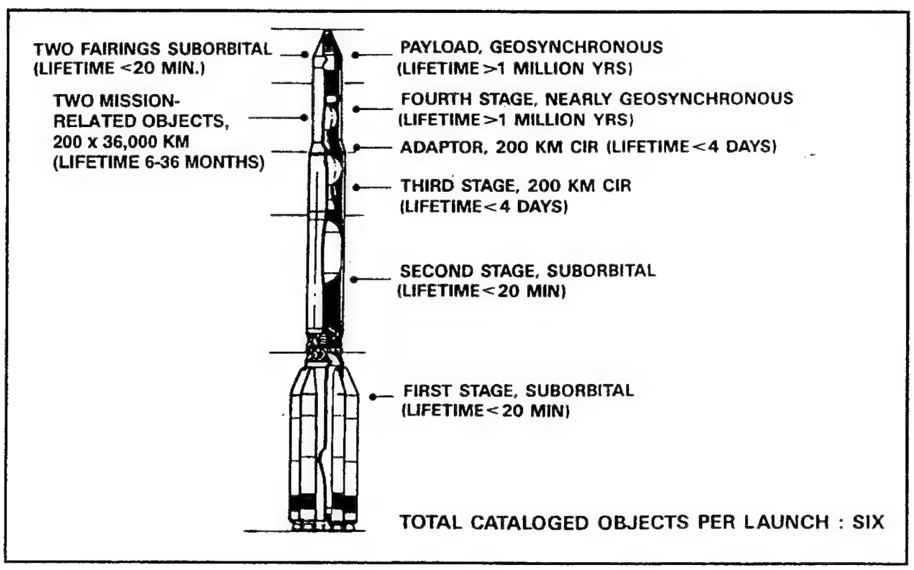

Figure 3. Typical Proton launch debris. [From National Research Council, 1995]

b. Mission-related Debris

This type of debris is released as a result of a spacecraft's deployment, activation, and operation. Some of these items consist of the following: parts of explosive

bolts, spin-up and spring-release mechanisms; packing devices and release cords securing solar panels and other appendages; lens covers; and objects thrown away or dropped during manned activities. The amount of debris can be quite large, but is diminishing as designs are adopted which no longer release such objects. Much of this mission-related debris is small and cannot be detected and cataloged by any surveillance network. [National Research Council, 1995]

One other type of debris worth discussing is solid rocket motor (SRM) ejecta. These motors are typically used to transfer spacecraft from low altitude parking orbits in LEO to a GEO orbit. Their fuel is a mixture of aluminum particles (used to dampen burn rate instabilities) and propellant. During the burn process, a large amount of aluminum oxide (Al_2O_3) dust is formed and ejected in the exhaust plume with a characteristic diameter of 10 microns; as many as 10^{20} particles may be generated. Though these particles have relatively short orbital lifetimes, it appears that there is a high average on-orbit population present at any one time. This long-term exposure of payloads can cause erosion of exterior surfaces and can degrade items such as optical windows and solar panels.

Another type of ejecta, though much smaller in number, is 1 cm or larger sized chunks of unburned SRM propellant called slag. This slag will not finish burning outside the pressurized rocket motor body.

c. Fragmentation

This type of debris poses the greatest threat to present and future orbital spacecraft. This debris is created from spacecraft breakups and the products of deterioration. There have been 124 known breakups since the first one in June, 1961. Of the 8100 cataloged objects produced by this source, over 3100 still remain in orbit. This amount is 40% of the U.S. space object catalog.

Fragmentations that are the result of explosions are the dominant mechanism in the creation of larger-sized debris. Reasons for explosions are: (1) propellant-related

explosions (high energy explosions), (2) catastrophic failure of internal components such as batteries, (3) failure of low pressurized tanks (low energy explosions), and (4) intentional destruction. Fragmentations can also be caused by a collision with another orbiting body, however there have been no such events confirmed. [The National Science and Technology Council, 1995]

Debris fragments created by the deterioration of products used on spacecraft are generally believed to be caused from the effects of atomic oxygen, solar radiation, and thermal cycling. Most of these debris particles are less than 0.05 cm in size and depart the spacecraft with low relative velocities. These fragments are items such as pieces of thermal blankets, protective shields, solar panels, and the flaking of small paint chips from spacecraft; it is thought that atomic oxygen erodes the organic binder of the paint. Paint is used extensively on both rocket bodies and spacecraft for thermal control. However, it was not until a paint chip (<1mm in diameter) caused an impact crater on the window of the STS-7 Shuttle mission in 1983 that the magnitude of this problem was fully recognized [National Research Council, 1995]. Table 1 lists the currently known causes of fragmentations.

Cause	**% of Events**	**% Fragments Still in Orbit**
Unknown	22	43
Propulsion Related	36	42
Deliberate	38	13
Systems Related*	4	2

* Electrical, command and control systems

Table 1. Causes of satellite fragmentations. [From The National Science and Technology Council, 1995]

d. Non-functional Spacecraft

<u>The majority of spacecraft in orbit are non-functional</u>. Once they have reached their end of life (EOL), by either termination or malfunction, they are left in their final orbit or in some cases are reorbited to a slightly higher or lower altitude. Once a GEO spacecraft's maneuvering propellant is expended it will begin its free motion due to Earth and luni-solar perturbations. Essentially, it will trace a larger and larger "figure-eight" as

seen from Earth; the maximum inclination reached will be approximately +/-15 degrees and its longitudinal position will no longer be constant. [International Academy of Astronautics, 1993]. Therefore, most GEO spacecraft are reorbited to a disposal orbit at EOL to preclude the risk of collision with a functioning GEO spacecraft. LEO spacecraft can be reorbited to higher altitudes resulting in much longer orbital lifetimes, or they can be transferred to orbits of 600 km in altitude or below where the expected orbital lifetime is 25 years or less.

C. TRACKING AND DETECTION

1. Tracking

a. Russian Space Surveillance System (SSS)

This system is operated by the Russian military. It consists of 10 radars that operate in either the very high frequency (VHF), ultra high frequency (UHF), or C-band frequency ranges and 12 optical and electro-optical facilities. The radars are used to detect and track objects in low Earth orbits, while the optical and electro-optical facilities are employed for high orbit detection and tracking. These Russian facilities are located across only one-half to two-thirds of the eastern hemisphere, and all are above 40 degrees north latitude. This causes some major breaks in observation; the SSS catalog does not include a large portion of GEO objects and the tracking of highly eccentric, low inclination orbits is periodic. See Figure 4. [National Research Council, 1995]

The data collected is processed at the Russian Space Surveillance Center and then entered into their space object catalog; identification of detected objects, updates of space object orbital elements, planning for future observations, orbital lifetime determination, and sharing of information with other space programs are also performed by the Center.

b. U.S. Space Surveillance Network (SSN)

This network is operated by the U.S. Space Command in the Cheyenne Mountain Complex, Colorado Springs, Colorado. It consists of more than 20 radar and optical sensors, most of which are tasked on an "as-needed" basis. Like the SSS, radars

are used for low altitude and optical sensors for high altitude observation; there are some deep space sensor radars capable of detecting objects in GEO. The SSN sensors are much more globally located than those of the SSS.

The U.S. Space Control Center processes the collected data and generates/maintains a space object catalog. Orbital elements are then released back to the sensors to allow for continued tracking of detected objects; selected satellite operators and space system users are able to access this data. Launches and U.S. space shuttle operations in orbit are provided collision warning by the Space Control Center. [National Research Council, 1995]

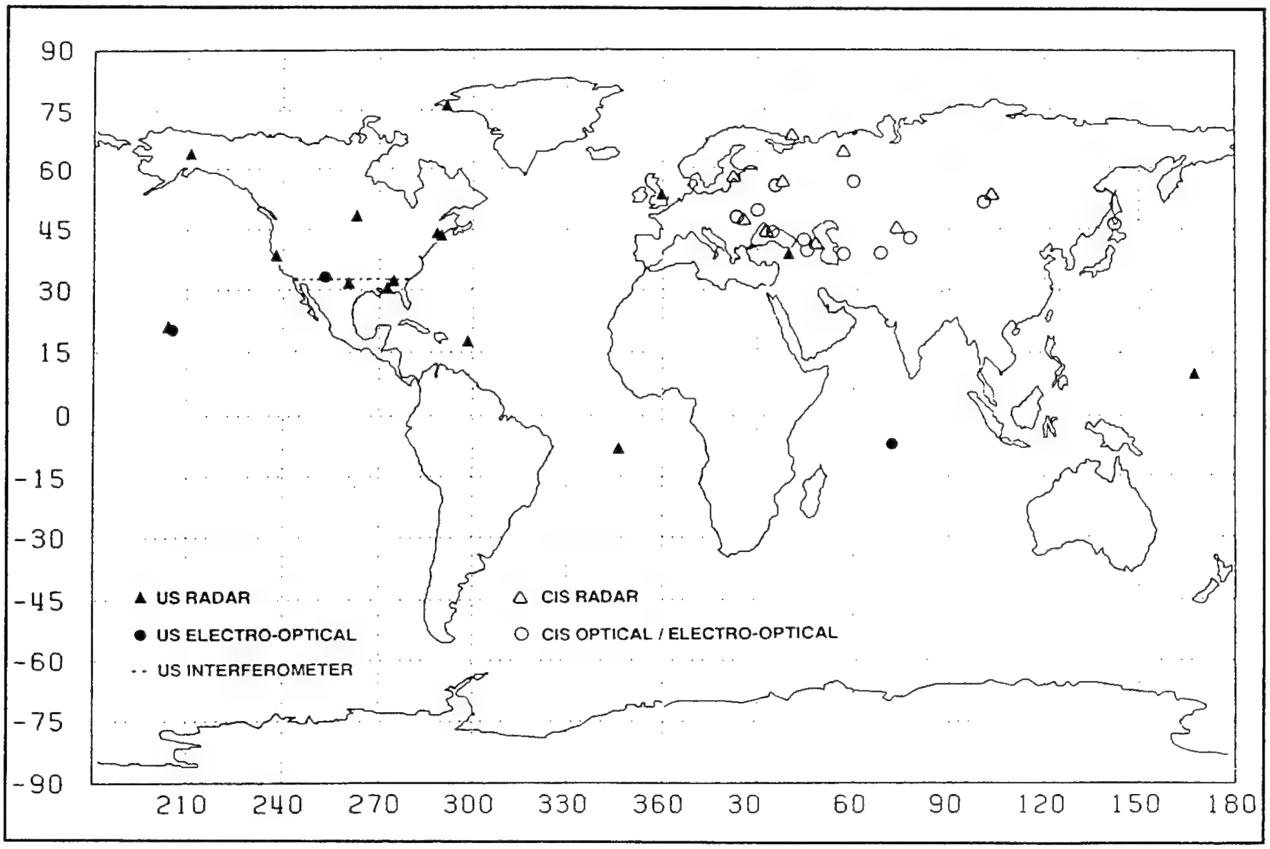

Figure 4. Sensors of SSS and SSN. [From National Research Council, 1995]

c. Comparisons

Both the U.S. and the Russian space surveillance systems are able to track objects as small as approximately 10 cm in LEO, however the SSN is considered more

complete for objects in the range from 10 to 50 cm. The U.S. Space Command's Cheyenne Mountain Complex in Colorado Springs has "The Bolt", a 4"x 1/2" bolt that is the approximate size of the smallest object that the SSN can track. As orbital altitude increases, the minimum detectable size for radar systems rapidly decreases so that by 5000 km, the smallest object detectable is about 1 meter in diameter. Above this altitude, optical telescopes are the primary means used for detection and tracking; they are capable of tracking 1 meter objects in GEO. However not all objects 1 meter or larger in size are tracked in GEO. It should be noted that both systems actually underrepresent the total of objects in highly elliptical orbits (HEO), high altitude circular orbits, and in low inclination orbits. This is a function of the high altitudes in the first two instances, and a function of the relative lack of sensors at low latitudes in the latter case.

2. Detection Facilities

The following are descriptions of a few of the sensors which make up the SSN and which employ some of the best technology in the world used for space debris detection.

a. Goldstone Deep-Space Communications Complex

This 3 cm wavelength radar has been used to collect orbital debris data, though not originally designed nor intended to do so. Goldstone is capable of detecting 2 mm objects at 1000 km altitude; the mode of collection is to generally "look" straight up (90° elevation) and then count the debris that passes through the radar's beam (beam park mode). Over one such collection period, Goldstone was able to detect roughly 150 objects larger than approximately 0.2 cm in diameter. Full-time debris observations using Goldstone are very limited due to its primary mission commitment to monitor deep space missions. [The National Science and Technology Council, 1995]

b. Haystack Radar

Also a 3 cm wavelength radar, the Haystack radar is located near Boston, Massachusetts. It is one of the most powerful radars in the world. Like the Goldstone radar, it has been used in the beam park mode to monitor the orbital debris population for

the last four years; it can detect a 0.3 cm object at 350 km altitude to a 0.7 cm object at 1400 km altitude. If the radar is used to detect objects near the horizon (south-pointing mode), the smallest object detectable is about 1 cm. [National Research Council, 1995]

c. *Liquid-metal Mirror*

One of the more interesting devices used to measure the population of small orbital debris is a 3 meter diameter telescope mirror located near Cloudcraft, New Mexico. The telescope's mirror is formed by rotating a pool of liquid mercury in order to maintain the necessary parabolic shape for the reflecting surface. It is able to detect debris as small as 2.5 cm at 900 km, and less than 10 cm at GEO. This type of mirror costs 10 times less than its equivalent glass mirror. [Orbital Debris Monitor, 1996]

d. *Air Force Maui Optical Station (PL/AMOS)*

Located at the Phillips Laboratory on the island of Maui, Hawaii, the goal of AMOS has been to estimate the debris population and to develop techniques to increase the detection sensitivity in order to detect and track smaller, thus uncataloged, debris. AMOS uses a Ground-based Electro-Optic Deep Space Surveillance (GEODSS) telescope as a detection sensor which records a video signal for later processing and display. [Maclay, 1995]

In spite of the above capabilities of the U.S. sensors, there is still much that can and should be accomplished in the study of space debris. One of the findings of the National Research Council's Committee on Space Debris is worth noting [National Research Council, 1995]:

> There has been no systematic approach to sampling space for orbital debris; most sampling to date has been performed when the opportunity arose, resulting in a series of investigations that studied a limited region of space over a limited amount of time. There is a need for national or international strategies to help prioritize detector development, data collection, and analysis of historical and new data. Such strategies are necessary to gain a better understanding of the sources of small and medium debris and the variations in these populations with respect to altitude, inclination, and time.

Figure 5 shows an estimate of the debris population in LEO derived from data collected from the various SSN sensors. Much of the data was collected from NASA's

Long Duration Exposure Facility (LDEF) which was an *in situ* debris detector which spent 63 months (1984-1990) in LEO orbit before being retrieved for analysis.

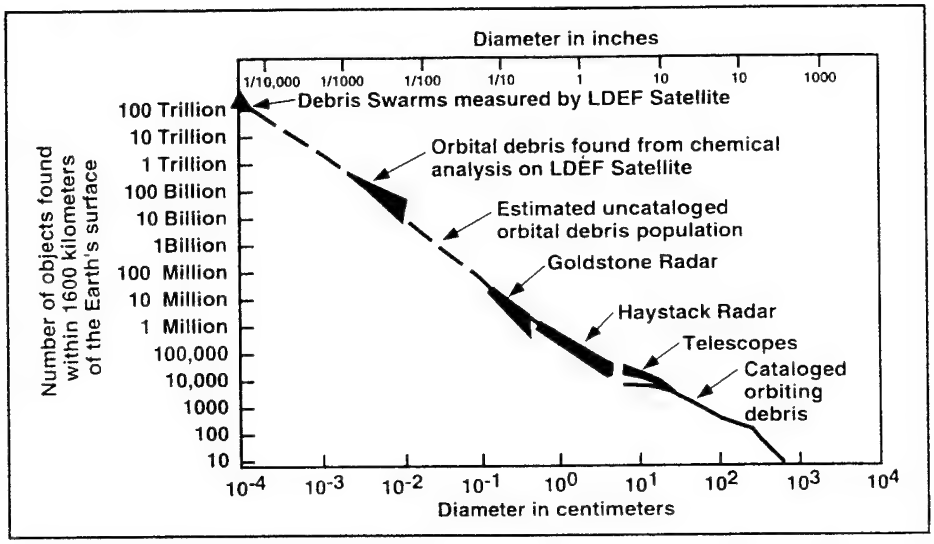

Figure 5. LEO debris population estimate from various sensors. [From National Research Council, 1995]

D. FACTORS AFFECTING DEBRIS

1. Fragmentation Forces

Some of the causes for spacecraft fragmentation have been discussed above. However, the following discussion will focus on the effects of an explosive breakup or collision upon the debris that is generated.

Right after fragmentation occurs, the debris will scatter at various velocities. These velocities can be broken down into *tangential, radial, and normal components*. They affect each piece of debris as follows: tangential velocity will increase/decrease the perigee and/or apogee and thus the eccentricity; radial velocity will change the eccentricity; and a normal component will change the inclination of the initial orbit. As a result of these various velocities, the debris will form a toroidal cloud which will continue to spread until is bounded only by the limits of the maximum altitudes (normally several hundred kilometers) and inclinations. See Figure 6. This debris dispersion will eventually manifest itself as a thin shell about the Earth with a hole at each pole. The rate of dispersion is a function of the magnitude of the velocity components and the orbital characteristics of the spacecraft;

the larger the components, the faster the evolution takes place. [National Research Council, 1995]

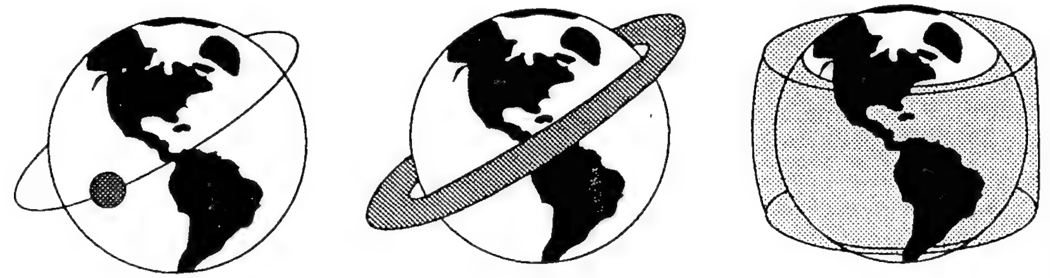

Figure 6. Evolution of a debris cloud. [After National Research Council, 1995]

2. Natural Forces

For LEO space objects, there are really only two major perturbations that will markedly affect and therefore significantly reduce orbital lifetimes.

a. *Atmospheric Drag*

Atmospheric drag is the principal force acting on space objects below 600 km in orbital altitude. Orbital energy is lost through drag forces created when the object encounters the upper reaches of the Earth's atmosphere; this eventually causes the object to spiral into denser atmospheric regions where it will usually burn up due to friction effects. The rate at which a space object losses altitude is a function of its cross-sectional area, mass, and the atmospheric density. This relationship for the acceleration due to drag, a_D, is shown by equation 1. [Space Mission Analysis and Design, 1992]

$$a_D = -(1/2)\rho(C_D A_c/m)V^2 \qquad [1]$$

where

ρ = atmospheric density

C_D= coefficient of drag

A_c = satellite cross-sectional area

m = satellite mass

V = satellite velocity w.r.t. the atmosphere

The atmospheric density at any given altitude will vary due to the 11-year solar cycle; it can differ by more than a factor of 10 over the 11-year cycle. [National Research Council, 1995] The last two peaks occurred in 1981 and 1991. An increase in solar activity will heat up the Earth's upper atmosphere. This expansion increases the atmospheric density, with the result being an increased orbital drag during solar maximum periods. Figure 7 shows the predicted orbital lifetimes for objects in circular LEO. The two lines are given for each object in order to show the solar cycle effects. Objects with high cross-sectional area-to-mass ratios decay much faster than objects with low area-to-mass ratios. Because it is hard to predict solar cycles and due to the uncertainty in calculating area-to-mass ratios of space objects, orbital decay predictions are very difficult to determine.

b. Solar Radiation

Solar radiation causes periodic variations in all of the space objects' orbital elements. Again, it is strongest if the object has a high area-to-mass ratio. The magnitude of the solar radiation acceleration, a_R, is shown by equation 2. [Space Mission Analysis and Design, 1992]

$$a_R = -4.5 \times 10^{-8} (A/m) \quad \text{, units m/s}^2 \qquad [2]$$

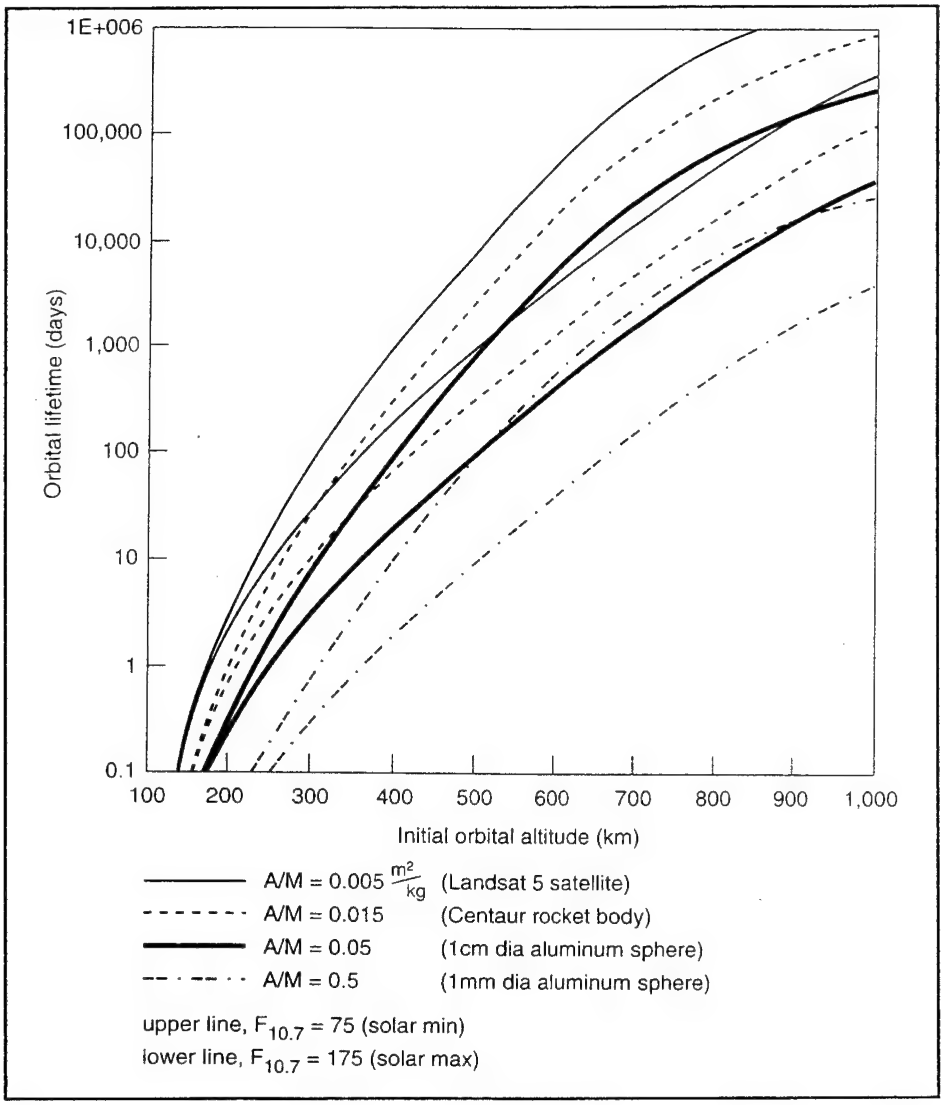

Figure 7. Orbital decay time versus altitude. [From National Research Council, 1995]

The "*cleansing*" effect on space objects during high solar cycle periods is vastly diminished at higher altitudes; the result is a steady increase of man-made objects. <u>Once medium Earth orbits (MEO) and GEO altitudes are reached, there are no significant natural forces present to aid in space object decay</u>. Objects in GEO have lifetimes in excess of one million years. See Table 2 for a comparison of orbital lifetimes of an average-type satellite in circular orbit. [The National Science and Technology Council, 1995]

Orbit altitude (km)	Lifetime
200	1 - 4 days
600	25 - 30 yrs
1000	2000 yrs
2000	20000 yrs

Table 2. Lifetime of circular orbits. [After Flury and McKnight, 1993]

E. DEBRIS CHARACTERISTICS

1. Orbital Regions

Space, much like Earth, is not a universal dumping ground for debris. Areas of higher usage will contain the vast bulk of the orbital debris population. Because of the desirable qualities of these orbits and the increasing demand placed on them, they will continue to see an increase in debris generation.

a. LEO

These orbits pertain to altitudes below 2000 km. It is here that the bulk of the world's satellites are found. Most are either in circular or near-circular orbits with orbital periods from 90 - 150 minutes. These orbits require the use of much smaller launch vehicles to place payloads in orbit, or one large vehicle can be used to place up to 10 satellites in orbit. Another factor for LEO use is its proximity to Earth. These lower altitudes allow for higher resolution images to be taken by remote sensing satellites. Also, it is at the LEO altitudes at which *human operations* currently take place. Space Shuttle missions generally take place at less than 600 km, the Mir space station is between 350-450 km, and the planned International Space Station will operate at 350 - 500 km in altitude.

b. Sun-synchronous

This type of LEO orbit rotates so as to maintain an approximately constant orientation with respect to the sun. This requires a certain amount of orbital precession with respect to the Earth every day. These orbits will pass daily or periodically over a particular geographic location at the same local time. This feature will give specific lighting conditions for a each point on the Earth as the spacecraft passes over head, a valuable effect

for remote sensing satellites. As such, one important orbital element feature of sun synchronous orbits is that they all have inclinations greater than 90 degrees; inclination increases for increasing orbital altitude. Altitudes near 900 and 1500 km are the most widely used.

c. GEO

These orbits are circular with orbital periods of 1436 minutes (~24 hours). Geostationary satellites (inclination = 0 degrees) appear essentially fixed in the sky and therefore do not need to be tracked by ground antennas, thereby simplifying communications. Geosynchronous satellites have a small inclination and trace a "figure-eight" in the sky; tracking is then required.

d. Semi-synchronous

These circular and near-circular orbits are at approximately 20,000 km in altitude and have a orbital period of 12 hours. The U.S. Global Positioning System (GPS) and Russian Global Navigation Satellite System make up these satellites found here.

e. Molniya

This highly elliptical orbit (eccentricity, e, is approximately 0.5; e = 0 for a circle) has an inclination of 63 to 65 degrees and an orbital period of about 12 hours. The apogee of this orbit is approximately 40,000 km. The perigee and apogee of this type of orbit will not rotate about the Earth but will remain over a fixed latitude (apogee is placed over the Northern hemisphere). Molniya orbits are used for early warning and communications services, as the satellite will spend about 10 of its 12 hour period above the mid-latitudes of the Northern hemisphere.

Figure 8 shows a "snapshot" depiction of the concentrations of the cataloged space debris found in the above orbital regimes.

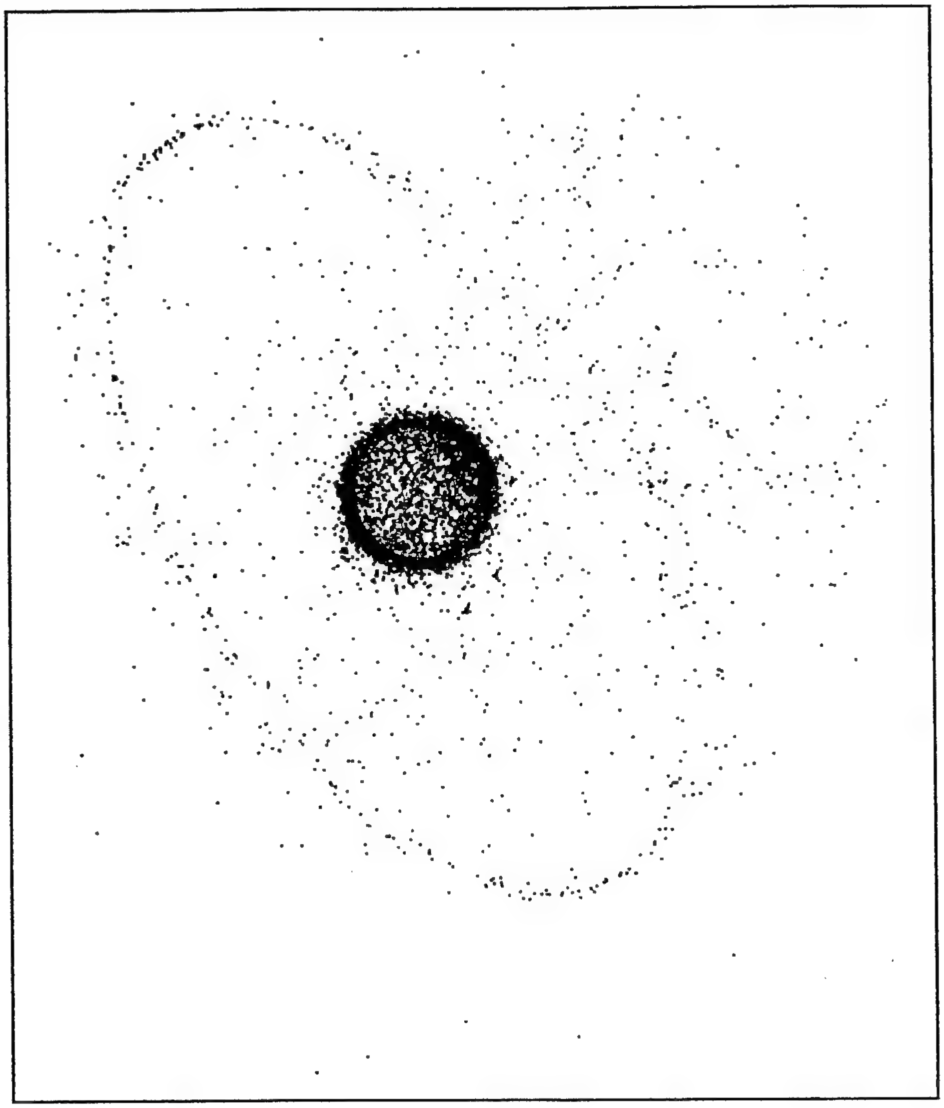

Figure 8. Cataloged orbital debris. [From National Research Council, 1995]

2. Debris Population

The previous section discussed the desirable effects of certain orbits/altitudes for spacecraft use. Of course, this directly affects the debris population found at these various altitudes. Further, there are principally three general size ranges used to categorize the debris environment. Table 3 shows a list of these categories.

Size Category	Appropriate Diameter	Approximate Mass	Detectability	Probable Damage to Spacecraft
Large	>10 cm	>1 kg	May be catalogable in LEO	Probable loss of spacecraft and possible cata-strophic breakup
Medium	1 mm-10 cm	1 mg-1 kg	Too small to catalog, too few for most in-situ sampling	Ranges from surface degradation through component damage and possible loss of spacecraft capability
Small	<1 mm	<1 mg	Detectable by *in situ* sampling	Degradation of surfaces and possible damage to unprotected components

Table 3. Debris size conventions. [After National Research Council, 1995]

It is important to note that only some of those objects larger than 10 cm have been numerically counted, i.e., catalogued. The populations of the medium and small-sized debris comes chiefly from extrapolations based on terrestrial and in-situ measurements and models.

a. Large Debris (> 10 cm)

Currently, the United States Space Command (USSPACECOM) "boxscore" of cataloged space objects (includes satellites and debris) is almost 8100. This represents only 0.02% of the estimated total number of objects to be in orbit. However, it also represents approximately 99.93% of the estimated total mass of objects in orbit. Recall the total estimated in-orbit mass to be 3,000,000 kg. At altitudes less than 2000 km, debris produced from fragmentation events dominates the cataloged objects. Between 2000 and 16,000 km, mission-related debris dominates, and at altitudes greater than 16,000 km, spacecraft and rocket bodies make up the majority. This shift in distribution is probably more due to the reduced capability of terrestrial sensors to detect smaller objects than any real change in composition of the debris population. [The National Science and Technology Council, 1995]

Since most of the cataloged objects are in highly inclined orbits (excepting GEO orbits), the relative collision velocities between a spacecraft and piece of debris will be rather high (10-12 km/s). This will give rise to hypervelocity collisions, i.e., collisions where the results of an impact are not dominated by material strength effects [National Research Council, 1995].

In short, since the fraction of objects that cannot be detected increases with altitude, it is possible that the total uncataloged large debris population could be more numerous than the total cataloged population [National Research Council, 1995]. Figures 9 and 10 show the space object population by altitude.

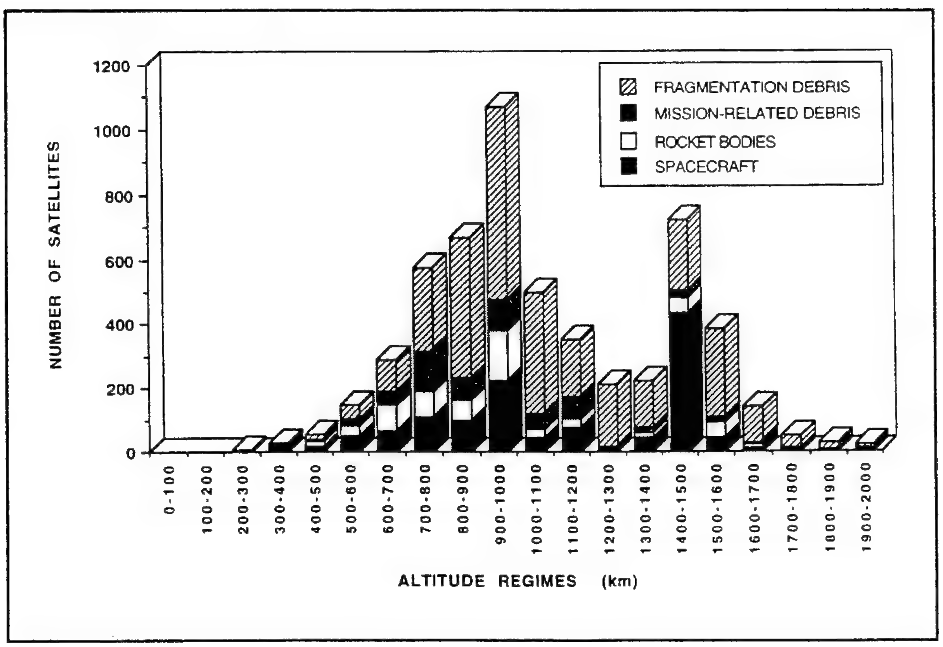

Figure 9. Low altitude space object population. [After National Research Council, 1995]

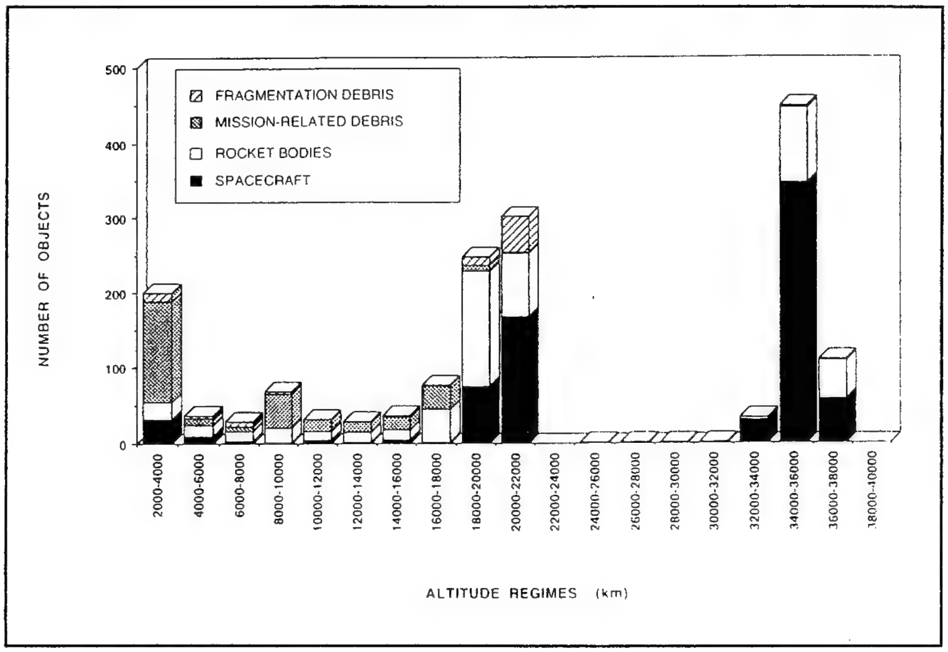

Figure 10. High altitude space object population. [After National Research Council. 1995]

b. Medium-sized Debris (1mm to 10 cm)

This size debris comprises 99.8% of the total number of pieces of debris larger than 1 mm, yet this only represents approximately 0.07% of the total mass in orbit. However, it is the number of objects this represents that is extremely important - estimated to be approximately 35,000,000.

Most of what is known about the population of this size of debris comes from the sampling of low-altitude, high inclination LEO orbits with terrestrial sensors. Refer to Figure 5 for the number of objects with diameters between 10^{-1} to 10^{1} cm; much of this data is derived from Haystack radar measurements. It is generally believed that the source of this size of objects is due to fragmentations and mission-related debris, with fragmentation debris consisting of the bulk. Further, this medium-sized debris will receive a greater range of break-up velocities than large-sized debris, thereby placing them into orbits with a larger range of inclinations, altitudes and eccentricities. However, since medium-sized debris generally have a higher cross-sectional area-to-mass ratio than large

size debris, it will experience a more rapid orbital decay. [National Research Council, 1995]

One potentially significant source of debris suggested from the Haystack data is coolant leakage from the non-functional cores of Russian Radar Ocean Reconnaissance satellites (RORSATs). Data suggests this large number (tens of thousands) of 0.6 - 2.0 cm sized debris located from 900 to 1000 km with inclinations between 60 and 70 degrees were generated from the sodium/potassium coolant used in the core. [National Research Council, 1995]

c. *Small Debris (< 1mm)*

Knowledge of this type of debris comes from in-situ experiments (e.g., LDEF), the Mir space station, the U.S. Space Shuttle, etc. All of these operate at altitudes less than 600 km, therefore any extrapolation of the data to higher altitudes is uncertain. The genesis of this debris is either mission-related or from fragmentation events (by breakup and deterioration). Compared with medium-sized debris, solar radiation and atmospheric drag have larger effects on small-sized debris because of even higher area-to-mass ratios.

One interesting experiment conducted concerning small debris was performed by the LDEF. It measured the existence of "*orbital debris swarms*", i.e., a very large increase in flux (3-5 orders of magnitude) that lasted for several minutes at a time; the overall lifetime of such swarms was generally several months. Possible sources of these swarms: the release of dust from spent rocket stages, atomic oxygen erosion of painted surfaces of objects in HEO orbits, the result of undetected breakups or a hypervelocity collision between medium-sized debris and a large object. [National Research Council, 1995]

3. Critical Density

One concept that can elicit a deeper concern for the orbital debris problem is that of a "*critical density*". <u>It is defined as the point at which an orbital region contains enough</u>

objects with sufficient mass so that the rate at which debris is created from collisions is greater than the removal rate of space objects. In other words, a "*chain reaction*" of fragmentation events occurs, though the time scale is on the order of decades or centuries. Once this reaction has started, it is self-sustaining; it cannot be stopped by a launch rate reduction. Figure 11 shows a comparison of the spatial density (objects/km^3) and critical density for LEO altitudes. Shaded regions are above the critical density. These regions will eventually see an exponential rise in the number of collision fragments.

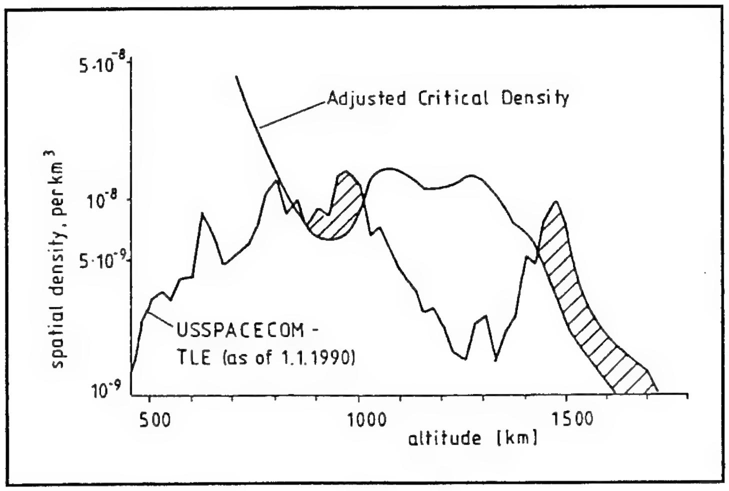

Figure 11. Critical density in LEO. [From National Research Council, 1995]

This collision growth will not occur over the whole LEO region. Areas of likely occurrence are: regions with an existing high debris flux (objects/m^2-yr), areas with small atmospheric drag effects, and areas with high collision velocities.

As such, the area below approximately 600-800 km may never exceed the critical density due to high atmospheric drag effects, though it could see an increase in debris injected into this region due to collisions at higher orbital altitudes [National Research Council, 1995].

The possibility of this "*collision cascading*" happening at GEO altitudes is uncertain, but will probably not occur. This is because collision velocities here are much smaller (500 - 800 m/s) than at LEO; this will create fewer fragments per collision. The

debris that is created will be spread over a much larger volume, thus increasing the spatial density slowly. Lastly, the debris flux at these higher altitudes is much lower than at LEO. Therefore, the debris population may well be sustained by launch traffic and in-orbit explosions.

Figure 12 shows the long term evolution of debris greater than 1 cm. Initial basic in-orbit population is approximately 60,000 objects > 1 cm.

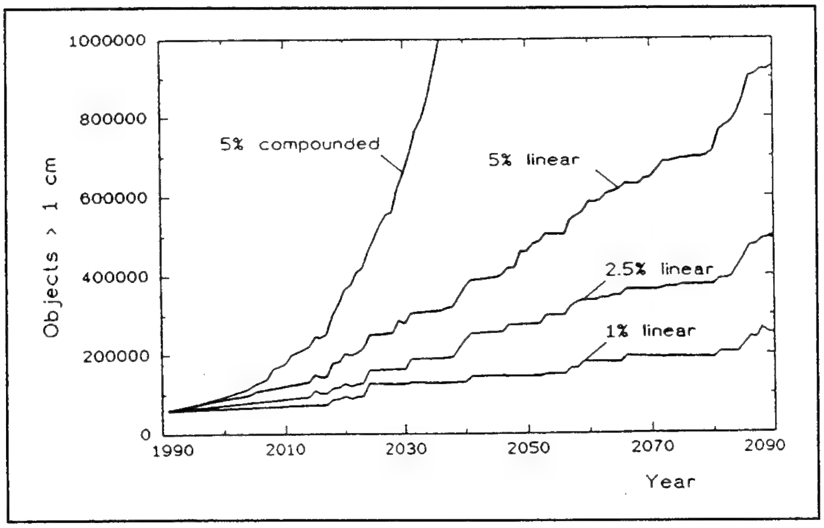

Figure 12. Long-term collision-cascading effects. [From International Academy of Astronautics, 1993]

4. Hazards

The probability of collision (PC) occurring between two objects is a function of the spatial density (SPD, objects/km^3) of the orbital objects in a given region, the collision cross-sectional area (A_c), the objects' relative velocity (V_{rel}), and the period of time the object is in the region being considered. Spatial density is heavily dependent upon the orbital altitude of an object, and to a lesser extent its inclination. It is an average value of the number of objects which reside within 50 km thick concentric volume shells. Figure 13 shows the spatial density of objects in orbit. This figure only categorizes those objects which are trackable; it has been estimated that there are approximately as many 1 to 10 cm debris fragments (generally non-trackable) in LEO than there are trackable objects.

Further, the PC between two objects occurring in any region increases with roughly the square of the number of objects in the region [National Research Council, 1995].

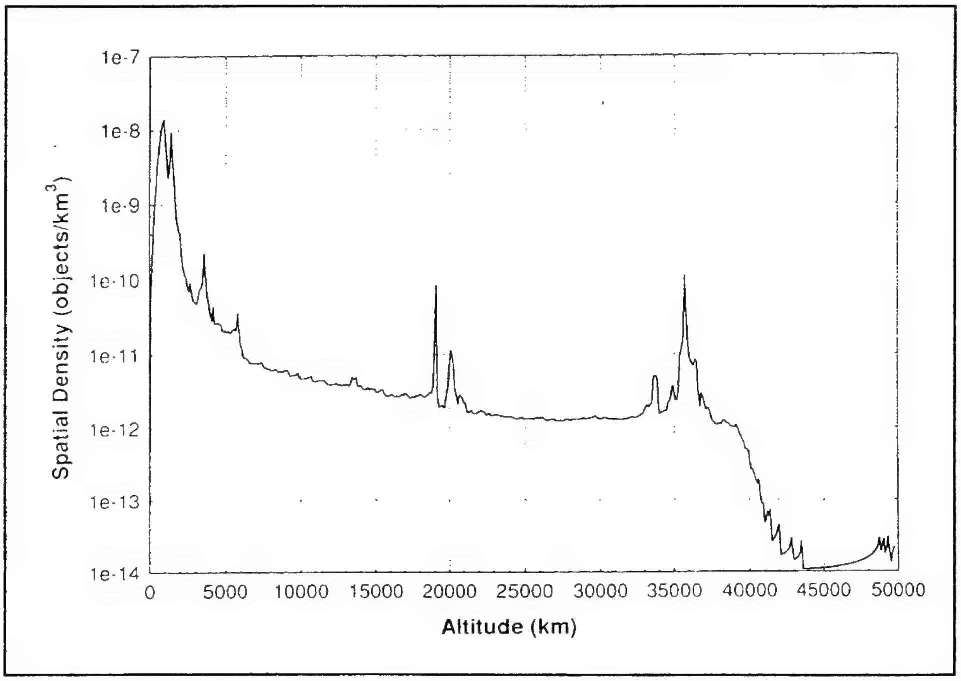

Figure 13. Spatial density of USSPACECOM catalog, 1994. [From National Research Council, 1995]

Equation 3 shows this relationship.

$$PC = 1 - \exp[-(SPD)(A_c)(V_{rel})(T)] \qquad [3]$$

where

SPD = number of objects/km^3

A_c = cross-sectional area of satellite, km^2

V_{rel} = relative velocity between satellite and object, km/s

T = time of exposure

As an example, the Mir space station has an A_c of approximately 270 m^2 and an average altitude of 350 km. If a V_{rel} of 10 km/s is assumed, then the probability of collision (with an object 10 cm in size or larger) over a one year period in orbit is approximately 2.0×10^{-4}, or about one collision every 5000 years. [McKnight, 1988]

Another method used to describe the probability that a spacecraft will collide with a piece of debris is based upon the debris flux (objects/m^2-yr) at a given altitude. The likelihood of being hit by a piece of debris is proportional to the cross-sectional area of the

satellite and the amount of time exposed to the environment. Figure 14 shows this cataloged object flux by altitude (assumed V_{rel} of 10 km/s). Again, this does not account for the risk due to uncataloged debris.

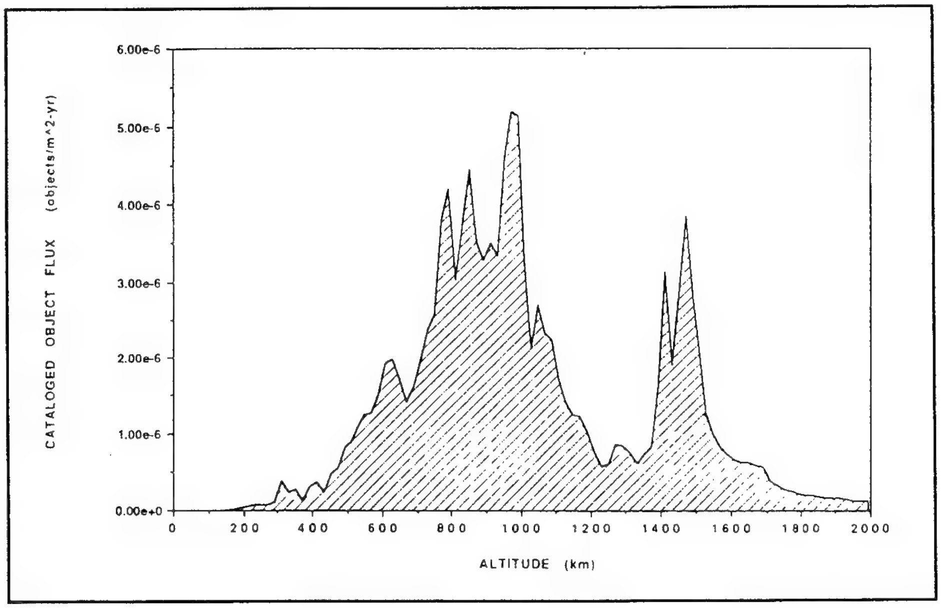

Figure 14. Flux of cataloged LEO objects. [From National Research Council, 1995]

Measurements taken using Goldstone, Haystack, and USSPACECOM flux data reveal that an average sized spacecraft (A_c=10m^2) in a "typical" LEO orbit (~800-1000 km) has a PC with a 1 cm size object somewhere between 1:100 to 1:1000 over a 10-year lifetime. Further, the spacecraft will be struck by about one 1 mm to 1 cm sized particle and anywhere from 100 to 1000 particles between 0.1 mm and 1 mm in size during the same 10-year period. [National Research Council, 1995] Figure 15 shows an estimate of large and medium sized debris from NASA's EVOLVE debris model.

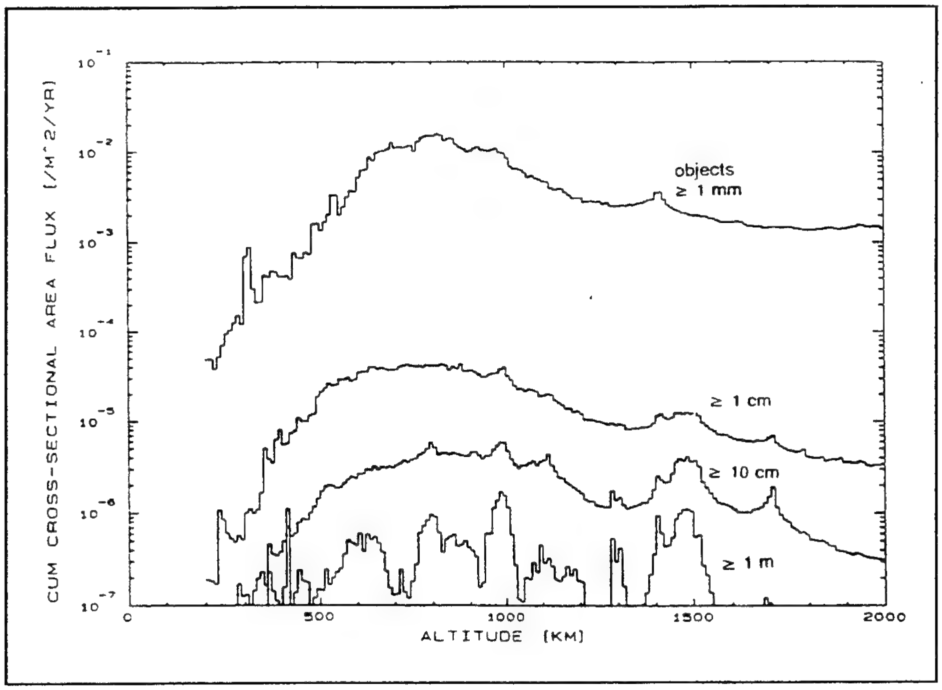

Figure 15. NASA prediction of LEO debris. [From National Research Council, 1995]

The discussion above centered upon objects in LEO. The threat of collision between objects in GEO is greatly lower than LEO, and sharply decreases with distance from geostationary orbit.

The effects of a collision between a spacecraft and a piece of debris is obviously dependent upon the mass of the debris and the relative velocity between the two objects; it is simply a transfer of kinetic energy instantaneously to the satellite upon impact. The manner in which damage occurs is complicated because of the typical hypervelocity impacts that occur. However, for spacecraft design it is useful to view the debris problem from the following perspective [Flury and McKnight, 1993]:

1. Debris less than 0.1 cm produce *surface erosion.*
2. Debris between 0.1 to 1.0 cm may *produce mission-degrading effects*, depending upon passive design provisions, e.g., shielding.
3. Debris larger than 1.0 cm can produce *catastrophic damage.*

As an example, a 1 cm aluminum sphere which strikes a satellite with a relative velocity of about 13 km/s has a kinetic energy equivalent to that of an explosion of 56 grams (0.12

pounds) of TNT. In other words, it would be like being hit by a 400-pound safe that was traveling at 60 miles/hour.

Of course, hazards to crewed missions take on a special importance. The International Space Station is being designed to withstand impacts to critical areas by debris up to 1.4 cm in size. Provisions are made such that if increased shielding is needed due to an increased debris threat, extra shields may be transported and deployed after the station is operational [The National Science and Technology Council, 1995]. The following quote sums up the hazards to man in space quite well [National Research Council, 1995]:

> Penetration of the pressure wall of a crewed spacecraft can lead to the loss of cabin pressure, secondary spall impacts on the interior, a light flash, and a pressure pulse. In addition, cracks created by the impact exceeding the critical crack length for a pressurized module can, under some conditions, lead to catastrophic fracture or the uncontrolled mode of crack propagation known as "unzipping".
>
> Astronauts or cosmonauts engaging in extra-vehicular activities are particularly vulnerable to the impact of small debris. On average, debris 1 mm in diameter is capable of perforating current U.S. space suits.

F. DEBRIS CONTROL

1. Background

There are really two considerations when developing methods to reduce the amount of debris a spacecraft will generate. The first is how the method's decrease in debris production relates to a reduction in the debris hazard to space operations. The second is the difficulty and cost of developing and implementing such a method. Viewed another way, the risk management associated with debris control consists of three measures of effectiveness - *debris prevented, mission penalty*, and the *cost penalty*. Today these are determined according to policies of the manufacturing and satellite operating companies, yet in the near future they could shift to more of a global, spacefaring context.

Debris control can be implemented during all three mission phases of a spacecraft's life cycle: launch and deployment, operations, and mission termination. Further, there are two methods for debris control - *prevention* and *removal*. Table 4 outlines some of these methods.

PREVENTION	REMOVAL
Design and operations	Retrieval
Expulsion of residual propellants and pressurants	Propulsive maneuvers (deorbit)
Battery safety (vent or fuse)	Drag augmentation
Retention of covers and separation devices	Solar sail
Propulsive maneuvers (reorbit)	Tether, Sweeping, Laser

Table 4. Methods to reduce debris population. [After Flury and McKnight, 1993]

Many of the preventative measures are already in widespread use. However, the release of mission-related debris could be greatly diminished by better design to eliminate such release. Further, all spacefaring nations could be encouraged to use disposal orbits, but this would require the operator to maintain a reserve fuel capacity which cannot be used for operational longevity.

The chief problem lies in the fact that once debris is put in orbit, only the cleansing action of the atmosphere will reduce the debris population; this is essentially limited to orbits of 600 km or less. Debris removal options in practice are, with the exception of deorbiting or using the Space Shuttle, non-existent. Drag augmentation would work best for altitudes of 600 km or less. Solar sail usage, which uses solar radiation pressure as the motive force to slowly change the orbital elements of an object, requires increased costs. Both the drag augmentation and solar sail methods will greatly increase the cross-section of the spacecraft thereby increasing the probability of collision with other space debris or spacecraft.

Using some sort of "debris sweeper" in orbit would require the ability to stop all sizes of debris expected to be encountered while at the same time not causing any further fragmentations upon debris impact. Also, the use of lasers has been suggested to "vaporize" debris. Again the problem of preventing any increase in the number of debris pieces upon an incomplete vaporization is present. Currently, there is no such technology

available that can accomplish either, and any development would be costly. <u>Prevention may well prove to be the cheaper route.</u>

2. Policies

The control of space debris before the mid-1980s was a practice in denial, though there were those individuals and groups who persisted in raising the issue of the debris population growth.

In 1963, an analyst at the Naval Research Laboratory (NRL) wrote two papers concerning space debris. He looked at the spatial density and the cataloged growth rate of detectable space debris. Accordingly, he developed an equation that did a good job in giving an estimate in the growth of the debris catalog. These papers were originally classified but were declassified in 1975.

However, by 1981, there had been a growing level of interest and awareness about orbital debris. In 1981, NASA published their "10-Year Space Debris Assessment Plan" which started a comprehensive research and development effort on technology, analysis and future policy in the space debris field. Also in 1981, the American Institute of Aeronautics and Astronautics (AIAA) issued a position paper which stated that space debris could not be ignored because of its potential permanence and hazard to spacecraft in orbit. Further, it stated that action was "imperative" and that there was, as of yet, no obvious or simplistic resolution evident. [McKnight and Johnson, 1994]

Not all talk on the space debris issue was given such a gloomy outlook. The U.S. Air Force Scientific Advisory Board issued an assessment in 1983 entitled "The Potential Threat to U.S. Satellites Posed by Space Debris". Their bottom line opinion was that space debris was "not a problem but further investigation is recommended." [Johnson and McKnight, 1994]. How this outlook was derived in the face of the many expert opinions around the world to the contrary is surprising. However, by 1987, their position had shifted to where they then believed:

> ...space debris represents a growing problem whose seriousness depends on future traffic and debris management. Even with careful control of future debris 'events' the level of debris...will increase through fragmentation collisions of orbiting objects.

One can hardly wonder if they had seriously looked at the problem in 1983. [Johnson and McKnight, 1994].

Fragmentation events are the single largest cause in the creation of space debris. From 1973 to 1981, eight Delta rockets (second stages) had exploded in orbit, producing an average of 185 trackable objects per event. These second stages were discarded rocket bodies; most had still contained several hundred pounds of hypergolic fuel. The problem was that it was somehow mixing and exploding. Therefore, in 1982, NASA instituted a requirement that requires the venting of all unspent propellants and gases from Delta upper stages to prevent such explosions. Since this policy was instituted, no explosions have been recorded.

By then it was clear that an implementation of a space debris policy would be beneficial to all space users, yet it was generally believed that mitigation practices would cost more than the expected gain. Further, it was viewed that infrequent users would have little to gain and thus no incentive to participate. Yet, in February 1987, the Department of Defense (DOD) issued a space policy which stated

> DOD will seek to minimize the impact of space debris on its military operations. Design and operations of DOD space test, experiments and systems will strive to minimize or reduce accumulation of space debris consistent with mission requirements.

By February 1988, President Reagan's National Space Policy included one statement on space debris [Johnson and McKnight, 1994]:

> All space sectors will seek to minimize the creation of space debris. Design and operations of space tests, experiments and systems will strive to maintain or reduce accumulation of space debris consistent with mission requirements and cost effectiveness.

Notice that this was just the DOD policy applied to all sectors of the space field. The 1988 National Space Policy was fairly steeped in mentioning economic practices in order to

stimulate the burgeoning commercial space launch capability of the nations' rocket manufacturers.

In November 1989, probably due to economic pressures competing with the implementation of space debris mitigation practices among the U.S. expendable launch vehicle (ELV) manufacturers and their drive to stay competitive in the world market, one sentence was added to the National Space Policy concerning space debris: "The United States Government will encourage other spacefaring nations to adopt policies and practices aimed at debris minimization." While this approach was already in place between non-governmental organizations, it was now an official U.S. government policy as well.

a. USSPACECOM

On 6 June, 1991, the USSPACECOM issued its "Minimization and Mitigation of Space Debris" - Regulation 57-2. Its first paragraph essentially restates the 1989 National Space Policy. The rest of the regulation assigns the following responsibilities for the operation, development, and conception of current and future space system [Johnson and McKnight, 1984]:

> a. Through its component commands, USSPACECOM will foster activities to better understand the evolution of space debris and the hazards of orbital debris to military, civilian and commercial space activities.
>
> b. Component space commands shall increase awareness of the requirement to mitigate space debris. They shall monitor space debris mitigation efforts of their material development activities, and within their authority, assure that mitigation of space debris is addressed explicitly in all space systems developments and upgrades.
>
> c. The design and documentation process for space system development, modification, or upgrade will permit clear identification of cost, schedule, and performance impacts of efforts to mitigate debris. System development or modification tradeoffs which affect the above in order to minimize debris shall be reviewed by and approved by the affected Service component space commands and coordinated with the United States Space Command.
>
> d. The justification for measures to mitigate and minimize debris or the effects of hypervelocity impact upon space systems should reflect robust technical investigation and research. Component Commands shall focus research to quantify cost, schedule, and performance impacts on system development.

Note especially part c. of the regulation. This was probably the first time that costing analysis was required to be generated in efforts to mitigate debris. Since the contractors who furnish spacecraft for government use are generally the same who supply the commercial market, any effort expended on their part to be in compliance with Regulation 57-2 might not be cost effective if it wasn't carried over to commercial applications.

b. NASA

On 5 April, 1993, NASA issued the first agency-wide binding guidance in order to implement the National Space Policy of 1989. It was NASA Management Instruction (NMI) 1700.8 - "Policy for Limiting Orbital Debris Generation". Its purpose was to limit the generation of orbital debris from all NASA programs and projects. Notably, it also defines orbital debris as:

> ...artificial, human-generated debris. Specifically, the term refers to the following: 1) payloads that can no longer perform their mission; 2) rocket bodies and other hardware left in order as a result of normal launch and operational activities; and 3) fragmentation debris produced by failure or collision. Gases and liquids in free state are not considered orbital debris.

The implementation of the policy was to be phased in and not to be considered retroactive. For example, a program beyond its preliminary design review (PDR) would only have to consider mission planning and operational procedures that affect debris generation; this was to minimize the costs involved. [Johnson and McKnight, 1994]

Therefore, in order to assist with the implementation of NMI 1700.8, a handbook was developed - NASA Safety Standard 1740 - "Guidelines and Assessment Procedures for Limiting Orbital Debris". This handbook is landmark as it establishes a consistent set of standards and criteria to be used by NASA programs and projects. It identifies five areas requiring debris assessment and states the guidelines for each. See Table 5. Further, it states guidelines for policy implementation, supplies methods for evaluating programs, and delineates reporting procedures and responsibilities.

Debris Assessment Areas	Guideline Description	Comments
Release of debris during normal mission operations	• Limit number, size, and orbit lifetime of debris larger than 1mm • Limit lifetime of objects passing through GEO	Includes staging components, deployment hardware or other objects larger than 1 mm that are known to be released during normal operations Tethers or tether fragments left in orbit are considered operational debris
Accidental explosions	• Limit probability of accidental explosion during mission operations • Deplete on-board stored energy at end of mission life	Includes systems and components such as range safety systems, pressurized volumes, bipropellant fuels, and batteries
Intentional breakups	• Limit number, size, and orbit lifetime of debris larger than 1 mm • Assess risk to other programs for times immediately after a test when the debris cloud contains regions of high debris density • No assessment of orbital hazard for breakups occurring below altitude 90 km	Intentional breakups include tests involving collisions or explosions of flight systems and intentional breakup during space system reentry to reduce the amount of debris reaching the ground
Collisions with large debris during mission operations	Assess probability of collision with intact space systems or large debris	Collisions with intact space systems or large debris will create a large number of debris fragments that pose a risk to other operating spacecraft. A significant probability of collision may necessitate design or operational changes
Collisions with small debris during mission operations	Assess and limit the probability of damage to critical components as a result of impact with small debris	Damage by small debris can result in both mission failure and failure to perform postmission disposal. A significant probability of damage may necessitate shielding, use of redundant systems, or other design or operational modifications
Postmission disposal	Remove spacecraft and upper stages from high value regions of space so they will not threaten future space operations	Options are to transfer to a disposal orbit or transfer to an orbit where the space system will reenter within 25 years. Disposal orbits are defined away from LEO, GEO, and semisynchronous (12 hour) circular orbit
Debris surviving reentry and impacting in populated areas	Limit number and size of debris fragments that survive uncontrolled reentry	This guideline limits human casualty expectation

Table 5. Debris assessment issues and guidelines. [After Maclay, 1995]

The following is an overview of the NASA handbook.

Debris released during normal operations: This is best described as mission-related debris. The goal is to limit debris 1 mm in size or larger (i.e., mass of 1mg or larger) as such debris could cause functional failure upon colliding with a spacecraft, or 10 cm or larger (mass of 1 kg or larger) which could cause a fragmentation event. This is accomplished by limiting the total area-time product to no larger than 1 m^2-yr. The area-time product is defined as the sum over all operational debris of the debris cross-sectional area multiplied by the total time spent below 2000 km altitude during the lifetime of each debris object. GEO debris objects created of 5 cm or greater in size are to be able to clear GEO altitude within 25 years. [Maclay, 1995]

Debris generated by explosions and intentional breakups: Here, the guidelines set the probability of accidental explosion during mission operations at 0.0001. Further, it also requires the depletion or venting of all on-board sources of stored energy upon mission completion. For intentional breakups, no debris larger than 1 mm will remain in orbit longer than 1 year; it also limits the area-time product to 0.1 m^2-yr. Additionally, any planned destruction of a structure as a reentry procedure must occur no higher than 90 km. [Maclay, 1995]

Debris generated by on-orbit collisions: The objective is to limit the probability of a spacecraft becoming a source of debris by collision with either man-made debris or meteoroids. A probability of 0.001 or less is set for a large object collision, and 0.01 is set for small debris of size sufficient to cause loss of control to prevent post mission disposal. [Maclay, 1995]

Post-mission disposal of space structures: The guidelines direct that objects will be removed from orbit in a timely manner or maneuvered to a disposal orbit where they will not interfere with future space operations. For LEO spacecraft, three options are available: atmospheric reentry, maneuvering to a disposal orbit, or direct retrieval to be accomplished within 10 years of mission completion. Figure 16 shows the storage options

for orbits above LEO. A probability of success of 0.99 or greater is required for the performance of post-mission disposal. [Maclay, 1995]

<u>Debris reentry risk</u>: The guidelines here seek to limit the risk of human casualty by limiting the size of debris components and structural fragments that survive reentry to 8 m^2 or less. [Maclay, 1995]

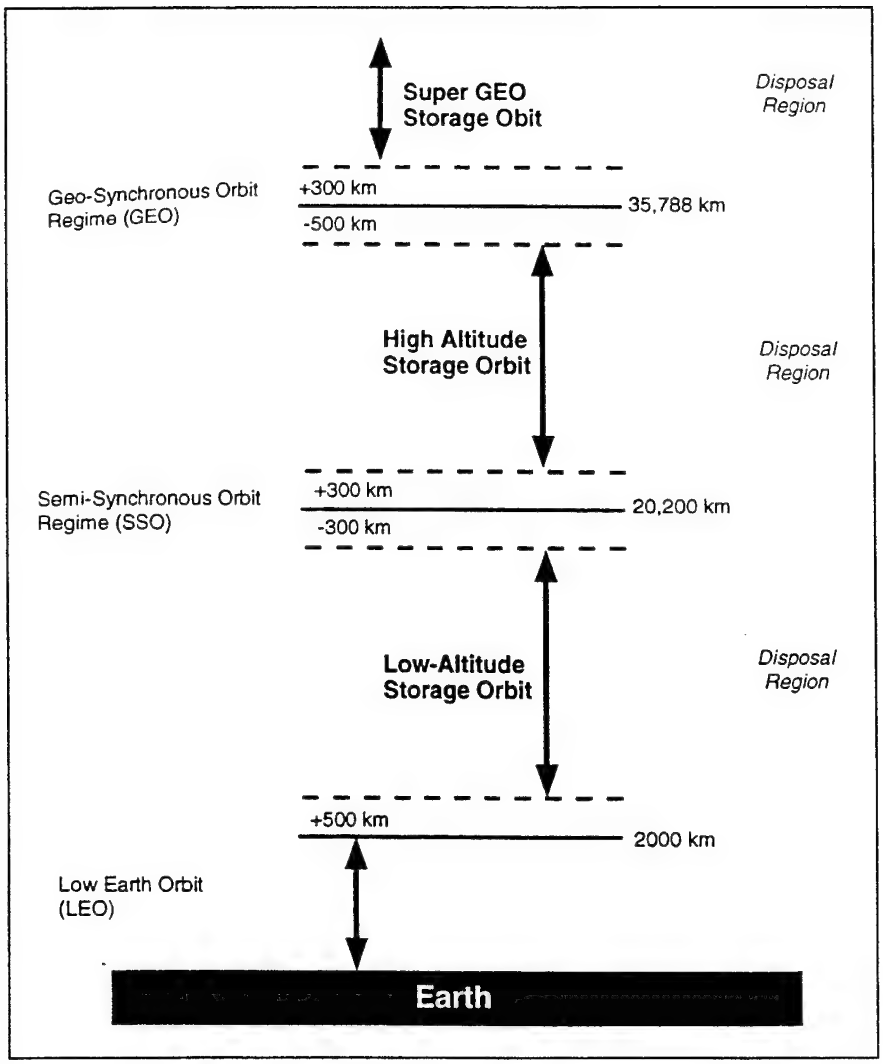

Figure 16. Storage orbit options for post-mission disposal. [From Maclay, 1995]

c. *Federal Communications Commission (FCC)*

This agency licenses and regulates commercial telecommunication satellites. Its authority is derived from the Communications Act of 1996 (previously, the

Communications Act of 1934, as amended); this authority encompasses the ability to issue orders and make rules. Satellites fall within the FCC's regulatory authority because they are considered *radio stations*.

It appears that the FCC does have the authority to prescribe rules concerning the disposal of telecommunications satellites upon the completion of their operational mission. The FCC could base its argument for such authority upon the premise that a non-operational satellite could collide with an operational satellite and therefore disrupt communications by radio. However, to date, the FCC neither requires their licensees to use GEO disposal orbits or to deorbit LEO satellites. This is probably due to the FCC's lack of an adequate technical basis for adopting such a requirement, and because most satellite operators already boost their GEO satellites to disposal orbits. This might change over the next decade when the introduction of large LEO satellite constellations arrive in orbit, thus possibly ushering in a whole new era for orbital debris. See Table 6 for some proposed LEO constellations.

System	Number of Spacecraft	Altitude (km)	Inclination
Teledesic	840	700	98.2
Iridium	66	780	86.0
Globalstar	48	1400	47.0
Odyssey	12	10360	55.0
Aries	48	1020	90.0
Ellipsat	24	500-1250	63.5
Vita	2	800	99.0
Orbcom	18	970	40.0
Starsys	24	1340	50-60

Table 6. Proposed LEO constellations. [From The National Science and Technology Council, 1995]

d. Department of Transportation (DOT)

On 24 February 1984, Executive Order 12465, Commercial Expendable Launch Vehicle Activities, ordered the creation of the Office of Commercial Space Transportation (OCST) in the DOT to license and approve private space launches. Its authority, provided by the Commercial Space Launch Act of 1984, is now codified in Title

49, U.S. Code. The OCST is to regulate the commercial space transportation industry, but only to the extent necessary "to ensure compliance with the international obligations of the United States and to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States." [OCST Strategic Plan, 1995]

This oversight is provided through the application of two distinct reviews - the mission review and the safety review; no license is issued before their completion. The mission review is primarily concerned with the launch vehicle, payload (U.S. or foreign) and the flight plan (path) in order to insure that U.S. responsibilities under international treaties (i.e., the Outer Space and Liability Convention) are met. Further, orbital debris, on-orbit safety, and reentry hazard issues and risks must be addressed. This includes an on-orbit risk analysis assessing risks posed by a launch vehicle to operational satellites as well as a reentry analysis assessing risks to third parties as a result of reentering debris or reentry of the launch vehicle or its components. The review must also consider how the mission will affect national interests. This authority extends to only those payloads that are not licensed by the FCC or the National Oceanic and Atmospheric Administration (NOAA). [Federal Register, 1996]

On 16 November, 1995, the OCST was transferred intact from the Office of the Secretary to the Federal Aviation Administration (FAA). The OCST is now known as the Office of the Associate Administrator for Commercial Space Transportation (AST). It should be noted that the AST, unlike the FCC, conducts extensive research. These areas of research include flight safety, launch sites, payload safety, reentry spacecraft and operations, standards, environmental issues, and space safety including orbital debris.

G. INTERNATIONAL TREATIES AND AGREEMENTS

1. Outer Space Treaty

This document entered into force on 10 October, 1967. Though it contains a basic philosophical approach on how the world's nations should undertake the exploration and exploitation of outer space, it is very general in scope when discussing any key ideas and

terms. As such, it does not implement any policy or put forth any measure on how to establish a policy which embodies the philosophy and principles of the treaty. However, it is apparent that the Outer Space Treaty can be considered the cornerstone of the foundation for the legal principles of outer space. Notably, Articles III, VI, VII, VIII, and IX are directly relevant in any discussion regarding space debris, and the provisions they contain apply only to a "State Party" to the Treaty. To date, over one hundred nations are signatories to this treaty.

- ***Article III***

This provision simply establishes the legal regime for outer space: it states that <u>the activities in the exploration and use of outer space, including the moon and other celestial bodies, will follow the established principles and rules of international law and the Charter of the United Nations</u>.

- ***Article VI***

<u>States shall bear *international responsibility* for their national activities in outer space, regardless of whether it was conducted by the government or by a private citizen /enterprise</u> (i.e., non-governmental entities); this established a new principle in international law. Further, these space activities of non-governmental entities must be authorized and continually supervised by the State in order to ensure they conform with treaties and international law. However, it should be noted that the scope with which these private space "activities" should be monitored is not delineated in the article. The U.S. has monitored activities as follows: NASA has provided supervision for private customers and users aboard its spacecraft; the Federal Communications Commission (FCC) has established regulations for non-governmental entities that own or use communications satellites; the Department of Transportation (DOT), through its Office of Commercial Space Transportation (OCST), has provided supervision for privately owned launch vehicle corporations; and the Department of State has overall authority over all extranational U.S. activities. [Goldman, 1988]

- ***Article VII***

This article establishes the *international liability* of a State when a space object is launched. A launching State, a State which procures a launch, or a State from whose territory or facility an object is launched is internationally liable for damages to another State and that State's natural or juridical persons (citizens); this liability also extends to damage caused by the component parts of the object. The damage could be terrestrial, in the air, or in outer space and on the celestial bodies. Therefore, if a Chinese Long March launch vehicle carrying a Motorola Iridium payload was involved in an accident, both nations would be liable for damages to a blameless third party.

- ***Article VIII***

This article provides for the registration and legally establishes the *ownership, jurisdiction, and control* over a spacecraft, to include personnel. The State on whose registry a space object is launched into outer space retains jurisdiction and control over the object while it is in space. Further, the ownership of a space object and its component parts is not affected by their presence in outer space or by their return to Earth. Also, any objects and component parts which fall to Earth are to be returned to the State of registry upon giving proper identification. If a spacecraft was not registered, it "would be considered a *rogue* and likely forfeit any legitimate status and protection under the Outer Space Treaty or international law." [Space Mission Analysis and Design, 1992]
Since these principles could apply to space debris, the issue of destruction or removal by one state of debris owned by another state is not clear under international space law, and could become a highly political matter.

Regardless, since it is clear that state ownership of the component parts of a space object is not forfeited when in space nor when a spacecraft becomes non-functional, it could be left up to the state to consent to the destruction or removal of this orbital debris. Further, if the state abandoned its right to the debris through a clear expression of intent, any destruction or removal by another state could be viewed as lawful; state property

remains state property under international law, unless it is expressly relinquished. [The National Science and Technology Council, 1995]

- *Article IX*

This article could be considered the "environmental protection" article, especially with regard to space debris. In accordance with the article, <u>States are obligated to conduct all their activities in outer space with due regard to the corresponding interests of other States</u>. In addition, States shall conduct exploration of outer space, including the moon and other celestial bodies, so as to "avoid *harmful contamination*" and shall adopt appropriate measures where necessary; any spoiling of space could be viewed as preventing the open access to space guaranteed to all States in the Preamble and Article I of the treaty. Further, States are also called upon to avoid adverse changes in the environment of Earth resulting from the introduction of "*extraterrestrial matter*"; the U.S. decision to quarantine astronauts and their spacecraft after the early spaceflights was partially in response to the dictates of this article [Goldman, 1988].

A State or its nationals planning to conduct an activity or experiment in outer space that could cause potentially "*harmful interference*" with the activities of other States is obligated to undertake "*appropriate international consultations*" before proceeding. Conversely, if a State believes that another State's activities may interfere with its space activities (or activities in general), consultation may be requested. However, such a consultation is not a legal obligation of the launching State. Therefore, the consultation will take place only if the State wants to participate and not if there is harmful contamination. [Maclay, 1995]

In spite of the above discussions, the most glaring deficiencies in the Outer Space Treaty have to do with a lack of definition of the terms as applied in the body of the treaty . It fails to define what "space debris" consists of, or to even provide a definition of a "space object". Similarly, neither are "harmful interference" nor "contamination" defined. For all these reasons, it was apparent that further work for an international consensus was needed.

2. Rescue Agreement

This agreement entered into force on 3 December, 1968. Most of the Agreement deals with the rescue and return of astronauts on land and on sea. It was short-sighted in its approach in that it was drafted to deal with 1960s spaceflight and man's expected flights to the moon. However, Article 5 of the Agreement does deal with the issue of the <u>return of space objects</u>. [Goldman, 1988]

Under the Agreement, a party discovering "*a space object or its component parts*", either in the party's jurisdiction or other jurisdictions not under any State control, shall notify the launching authority and the Secretary General of the United Nations. The discovering party is required, upon the request of the launching authority, to render such steps it finds "*practicable*" to recover the object or parts. If the discovering party believes that the object or parts is of a "*hazardous or deleterious nature*", the launching authority may be notified, which shall take immediate steps to eliminate possible danger or harm.

Other provisions are the requirement to return the object or parts upon request, and then only when the launching authority furnishes identifying data, and that all expenses shall be borne by the launching authority.

One of the more contentious issues in the Agreement was that of the meaning of "*practicable*" steps a discovering party might take in the recovery of an object or part. Foreign relations between two States at the time of discovery might well determine what is "practicable". Clearly, this agreement has outlived its usefulness in today's world.

3. Liability Convention

This is the most relevant treaty with regard to orbital debris; it entered into force on 1 September, 1972. <u>The treaty establishes a standard of strict liability for damage on the surface of the Earth or to aircraft inflight which is caused by space-related activity</u>. Simple negligence or fault is no defense. Such a draconian philosophy (by today's developing legal standards for space) was really created because of the general world view (in the 1960s-early1970s) that space was the domain of two elite players, the U.S. and USSR.

The feeling was that they alone should bear the risk for their space activities. No ceiling was set on the compensation that claimants may seek and obtain. [Goldman, 1988]

There are two exceptions to this strict liability standard. The first case is when damage occurs, other than on Earth, to a space object of one state by the space object of another State. The latter is liable if the damage is due to its fault or the fault of persons for whom it is responsible (Article III). In cases of joint liability, damage compensation will be apportioned between the States at fault; if this cannot be determined, then it will be divided equally among them (Article IV). The second case, outlined by Article VI, would exonerate a State from strict liability if the damage "resulted either wholly or partially from gross negligence or from an act or omission done with intent to cause damage on the part of the claimant State or of natural or juridical persons it represents" [Goldman, 1988].

However, the convention never delineates as to what constitutes "*fault*". Further, that fault must be proven. If it is believed that any production of orbital debris during space debris shows negligence, then the fault standard is really no different than the strict liability imposed when space objects cause damage on the Earth's surface. Others believe that some form of negligence standard is appropriate [The National Science and Technology Council, 1995]. Because current space technology does not allow for debris-free operations in space, "*reasonable*" attempts by a State to control its space objects in order to prevent *foreseeable* damage might limit, or erase its liability. An example of fault might be "leaving old satellites and spent parts in orbit..at least regarding special orbits of great importance, like GEO orbits or orbits used by manned spacecrafts and space stations" [Maclay, 1995]. In view of this, States responsible for damages may be unwilling to pay compensation for a fault that is not mentioned in a treaty.

Therefore, it is apparent that many factors will come into play to determine "reasonable" actions and "foreseeable" damage. This will certainly change with improving technology and would have to consider "the proximity of other space objects, the reason

for the creation of the debris, and the feasibility of providing warnings to States potentially affected by the debris". [The National Science and Technology Council, 1995]

By 1972, there had been 34 reported cases of space objects (satellites and rocket stages) causing re-entry damage. In 1979, the U.S. Skylab reentered over Australia and left pieces as large as 500 kg strewn about uninhabited areas; the extent of "damage" was never known. However, the most notable case involving debris reentry and damage occurred on 4 January, 1978, when the Soviet Ocean Surveillance Satellite, Cosmos 954, burned up in the atmosphere and fell over 500 km^2 of three Canadian provinces. Cosmos 954 had a nuclear power source which contained approximately 50 kg of uranium; all but two of the pieces found were radioactive, some of them lethally so. [Kuskuvelis, 1993]

Canada made a claim on 23 January, 1979 against the USSR in the amount of C$6 million for damages caused by Cosmos 954; they based their claim on the Liability Convention and argued that Cosmos 954 and its nuclear reactor were "space objects" as defined in Article I. On 2 April, 1981, the USSR paid Canada C$3 million "in full and final settlement on all matters connected with the disintegration of the Soviet satellite Cosmos 954..." [Kuskuvelis, 1993]. Since the USSR never formally admitted liability, it was unclear as to what damages the USSR paid for. Also, because the settlement procedures of the Convention were not invoked by Canada, it is argued that the Convention was never applied to the event and therefore any legal interpretation is without merit. [Baker, 1989, p. 66] However, it was generally recognized that "damage to property of States" (Article I) did include that damage caused by nuclear contamination.

Regardless of the classification of a space object (or refuse) falling to Earth and causing damage, it seems apparent that it can be solved either by application of the Liability Convention or by international customary law; it may not be without difficulty though. Conversely, existing law does not seem to offer any firm foundation to successfully conclude any damage issues involving space debris striking a space object. [Maclay, 1995]

4. Registration Convention

Early in the space race, it was apparent to most nations of the world that the United Nations would provide the best forum and therefore should be the focal point for international cooperation in the peaceful exploration and use of outer space. Accordingly, on 20 December, 1961, the U.N. General Assembly passed Resolution 1721 (XVI). One of the provisions of the resolution "calls upon States launching objects into orbit or beyond to furnish information promptly to the Committee on the Peaceful Uses of Outer Space through the Secretary-General, for the registration of launchings." Further, it was also stated that this information will be maintained in a public registry. [Resolution 1721, 1961]. This registration of space objects was not binding upon the U.N. members. Therefore, it was chiefly a political decision as to whether a spacefaring nation (i.e., the U.S. and USSR) would participate with full "disclosure". Space at this time was strictly a playground for strategic and military purposes.

However, by 1975, it was realized that closure was needed with the Outer Space Treaty's (Article VIII) reference to a State "on whose registry an object launched into outer space is carried..." and the provisions of the Liability Convention. The desire was to create a central registry for space objects, again to be maintained by the Secretary-General; however, *participation would now be mandatory.* Further, in order to assist in the identification of a space object (whose meaning was identical to that as stated in the Liability Convention), the following information would be required [Goldman, 1988]:

1) Name of launching State or States
2) An appropriate designator of the space object or its registration number
3) Date and territory or location of launch
4) Basic orbital parameters, including nodal period, inclination, apogee, and perigee.
5) General function of the space object.

Accordingly, the Registration Convention entered into force on 15 September 1976. <u>It assists in the assessing of liability and in the identification of ownership for the eventual</u>

cleanup of space debris [Goldman, 1988]. If there is more than one launching State, they will determine which of them shall register the space object. This convention was seen to be an aid in identifying a space object (i.e., orbital debris) which has caused damage, thereby helping the State suffering damage to seek redress from the associated launching State. If a damaged State cannot identify the space object which caused damage, other States, particularly those with space monitoring and tracking facilities, may be called upon to assist "to the greatest extent feasible" in the identification of the debris. [Goldman, 1988].

H. CONCLUSION

The magnitude of the orbital debris problem has long been ignored. If measures had been taken years ago, the debris "creep" now present might well have been avoided. Studies will continue in order to better understand and model the debris environment, yet action is needed today in order to minimize and in some cases, eliminate sources of debris. NASA's handbook for limiting orbital debris should be the model for all space manufacturers to emulate. It is clear, concise, yet is not capricious in it guidelines. However, it is unlikely that there will be unilateral acceptance of debris reduction standards; only a multilateral agreement will be able to pull the spacefaring nations together.

Possibly one of the only ways to reach a better understanding of the risk small to medium debris pose is to create a tracking system designed specifically for those sized objects; the SSN and SSS are not optimized for this type of collection. Further, the data collected could be entered into an international data base accessible to all interested parties.

Clear and concise definitions are needed in a new international convention on space debris. The fact that the term "space debris" is never found in any documents is the fuel of dissent for those who believe the treaties now in force never intended to cover such objects. From an objective viewpoint, this can hardly be the case. Unfortunately, man desires to regulate space activities by civil law rather than common law - differing cultures, economic status, political and world views unfortunately dictate this. This is not lost upon U.S.

space providers, as they have the most to lose given unilateral technical decisions driven by U.S. law and policy.

Ultimately, the debris issue may come down to peer review and peer pressure. Most certainly the U.S. should lead the way in any measures taken. Yet the economic factors may well greatly influence decisions today, but at what cost tomorrow?

IV. ADDITIONAL TOPICS

A. BOGOTA DECLARATION

1. Background

This declaration is interesting as it was a unique attempt by eight equatorial States to proclaim sovereignty over the geostationary orbital segments above their territory. During a meeting held in Bogota, Columbia in late November - early December, 1976, these countries - Brazil, Zaire, Indonesia, Kenya, Columbia, Congo, Uganda, and Ecuador - adopted a declaration which proclaimed that the GEO orbit is not a part of outer space. These countries claimed that the GEO orbit it is a physical fact whose existence is solely dependent upon its unique relationship with Earth-generated gravity. Further, they considered these orbital segments akin to natural resources and therefore claimed national sovereignty over them. [Zhukov, 1984]

The U.S. and Soviet response to this claim was that because of existing treaty and customary law, no claim or national appropriation of space was allowed; clearly twenty-two thousand miles up was obviously outer space. Additionally, the U.S. believed that the issue of governing the use of the geostationary orbit was a function of the International Telecommunication Union (ITU). [Goldman, 1988]

2. International Telecommunication Union (ITU)

The ITU performs functions on an international basis analogous to the role the FCC plays for U.S. domestic issues; it is one of the oldest international organizations and became a specialized agency of the United Nations after World War II. The ITU's charter is contained within the International Telecommunication Convention. Essentially, the ITU provides for the international registration, distribution, and regulation of radio frequencies and of the geosynchronous orbital slots. However in reality, the ITU is basically a place where such radio frequency registration is documented, in addition to providing a forum where differences between nations can be solved, usually through compromise and in the

interest of international cooperation. These differences are usually technical in nature, such as frequency interference between neighboring States.

At the time of the Bogota Declaration, Article 33 of the International Telecommunication Convention stated [Zhukov, 1984]:

> In using frequency bands for space radio services, members shall bear in mind that radio frequencies and the geostationary satellite orbit are limited natural resources, that they must be used efficiently and economically so that countries or groups of countries may have equitable access to both in conformity with the provisions of the Radio Regulations according to their needs and the technical facilities at their disposal.

It is apparent that all nations are afforded equal access to the GEO region; any deviation by allowing sovereignty over any portion would conflict with the above provision and the Outer Space Treaty.

However, in regard to the Bogota Declaration, several of the equatorial nations claimed such GEO sovereignty because of their desire to *protect* their populations from unauthorized direct broadcasts via foreign satellites. Their general fear was one of a "*cultural imperialism*" against the them (the receiver nation) by a dominant sender nation. Additionally, the Soviet Union and many other countries had also argued for years that "*prior consent*" is required from a receiver nation in order for another nation to broadcast across international boundaries. Such broadcasts are seen as violations of the Outer Space Treaty and the UN charter. [Goldman, 1992]

In view of this, the ITU has written regulations in order to limit this "technical spillover" by limiting the footprint of the satellite's broadcasting. Further, international agreements play an important part in the negotiation of trans-border satellite telecommunications flow.

On 10 December, 1982, the United Nations General Assembly adopted a resolution called Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting. This resolution essentially put forth that international satellite direct television broadcasting should be carried out in "a manner compatible with the sovereign rights of States, including the principle of non-intervention..." [Space Law

and Related Documents, 1990]. However, the United States rejected any legitimacy of this resolution.

3. Toward a Solution

In 1983, the nations that had put forth the Bogota Declaration had changed their position of sovereignty over the GEO slots. They now desired to see the establishment of "general principles to govern the national and equitable use of geostationary orbit" [Goldman, 1988]. This was basically seen as a way of reserving a "*fair share*" of the GEO slots for developing/third world nations. It is not clear if this tact was taken from a viewpoint that if the principle of national appropriation of space (i.e., sovereignty) was legitimized, these same nations could find themselves in a "*have-not*" position simply because some nations would already "own" considerable regions of space, i.e., the principle of non-appropriation of space by means of use or occupation would similarly have to be considered legitimate. [Zhukov, 1984]

Regardless, it was a fundamental opposition by developing nations to the longheld U.S. position of a "*first-come-first-served*" with respect to orbital slots; the U.S. believed any issues could be solved through technology improvements [Goldman, 1992]. However today, <u>ITU allocation of orbital slots is accepted throughout the world-body</u>, and is within the framework of the ITU. Article 12 of the International Telecommunication Convention states that the Radio Communication Bureau (of the ITU) will [International Telecommunication Union Convention, 1992]:

> carry out studies to furnish advice to Members with a view to the operation of the maximum practicable number of radio channels in those portions of the spectrum where harmful interference may occur, and with a view to the equitable, effective and economical use of the geostationary-satellite orbit, taking into account the needs of Members requiring assistance, the specific needs of developing countries, as well as the special geographical situation of particular countries.

B. TWO-DEGREE SPACING

Technological limitations of early satellites prevented them from being placed closer than four-degrees while in GEO positions. These limitations were the result of

unacceptable radio interference produced by internal components, and from terrestrial/adjacent satellite sources. Then, in 1983, the FCC published in the Federal Register a notice of inquiry that requested comment regarding shifting current policy to two-degree spacing for GEO orbits. The FCC reasoned that approximately 1500 new transponders could be put in orbit by the 1990s if the change was made. [Goldman, 1988]

There were chiefly two major concerns to the FCC inquiry. The first was one of economic concern, especially for those operators who used the 4.5-meter antenna dish. It was believed that undue economic hardship would be placed on the pioneer companies that had started the communications industry, i.e., the dishes would have to be replaced or upgraded, making capitalization costs overwhelming. Of course, satellite manufacturers and carriers would be on the other end of the economic ladder. Secondly, it was thought by the FCC that such a policy change would be looked upon by developing/third world nations as a huge "land grab" in space. [Goldman, 1992]

Regardless, the FCC did commit to the two-degree spacing. By 1986, in conjunction with agreements reached with the ITU and other nations concerning the fair allocation of these "new" GEO slots, the FCC had already allotted most of its slots for future U.S. satellite launches.

C. THE ANTI-BALLISTIC MISSILE (ABM) TREATY

1. Background

The ABM Treaty is unarguably the most important document germane to any discussion involving the policy implications in the development and testing of an anti-ballistic missile system. It is a bi-lateral agreement drafted in a period of détente between the Soviet Union and the United States. Both countries had experimented with ballistic missile defenses and had come to the conclusion that such a defensive measure would be easily countered by a buildup in strategic offensive arms. Therefore, not desiring to see another arms race begun, the U.S. and U.S.S.R. signed the Strategic Arms Limitation Treaty (SALT I) and the ABM Treaty in 1972.

Today, the Ballistic Defense Missile Organization (BMDO) overseas the development of three broad missile programs areas: Theater Missile Defense (TMD), National Missile Defense (NMD), and the Advanced Technology Program. TMD is concerned with the protection of U.S. forces, allies and other countries, to include areas of vital interest to the U.S., from theater missile attack. This includes population centers and fixed/mobile military units. It is the highest priority program today. NMD systems deal with the threat of a limited ballistic missile strike against the U.S. homeland. Today, this threat is labeled as a "rogue" attack by a Third World or terrorist group, or an "accidental" launch of a ballistic missile elsewhere. Finally, the Advanced Technology Program supports research on new technologies and offers viable options for existing system improvement.

In light of the above synopsis, it is really the relationship between the TMD systems and the ABM Treaty that has generated a great deal of political discussion, controversy and disagreement as to the intent and interpretation of the ABM Treaty vis-à-vis these systems. Therefore, the following provides a look at the different interpretations of the treaty the U.S. government has stood behind since 1972.

2. Traditional Interpretation

An ABM system is defined by Article II as "a system to counter strategic ballistic missiles or their elements in flight trajectory". Further, Article II goes on to define an ABM system as <u>currently</u> (1972) consisting of: ABM interceptor missiles constructed and deployed in an ABM mode, or tested in an ABM mode; ABM launchers; and ABM radars constructed, deployed or tested in an ABM mode.

It was evident when the Treaty was drawn up that the technology currently used for anti-missile purposes was not the "end of the line" for such systems. Further it was also recognized that new technologies under development would prevent any attempt to specify appropriate limits on them. President Nixon's belief in 1971 was such that any provisions drawn up between the two sides should not prevent the development and testing of future

ABM components in the fixed land-based mode, but that all other forms (air, sea, mobile-land, and space) of interceptors, launchers, radars, and components should be banned. Additionally, he stated that [Grabbe, 1991]:

> Our objective is to reach agreement on the broad principle that the treaty should not be interpreted in such a way that either side could circumvent its provisions through future ABM systems or components. We intend to handle any problems that may arise through the joint commission and the formal review procedures.

Therefore, in order to deal with these issues, two Articles were included - Article V and Article VI. Article V forbids the development testing or deployment of futuristic systems or components that are sea-based, air-based, space-based, or mobile land-based. Article VI expressly forbids the capability of non-ABM systems to counter strategic ballistic missiles or their components in their flight trajectory, nor to test non-ABM systems in an ABM mode.

One final key provision involves the wording of Statement D in the Agreed Interpretations signed in conjunction with the treaty in 1972. Agreed Statement D was added at the request of the U.S. Joint Chiefs of Staff in order to allow for the exemption of the development of a ground-based laser for a fixed land-based defense. Since this project was classified top secret and was in progress at the time, Statement D allowed for the development and testing of such a new technology for fixed land-based systems which protected a specific area, as allowed by the treaty. [Grabbe, 1991]

3. Broad Interpretation

1985, the Reagan Administration issued an interpretation of the treaty which supposedly took advantage of a "loophole" in the treaty permitting strategic defense development if it was based on technology that was not anticipated when the treaty was signed. The Administration essentially saw Statement D as an escape clause from the provisions of Article V and VI of the treaty. They claimed that Article V's prohibition on the testing of air or space-based components applied only to those technologies in existence

in 1972, and likewise with Article VI - testing components in an ABM mode or with an ABM capability did not apply to exotic technologies. [MacDonald, 1989]

President Reagan "agreed in principle, but not in practice" with this interpretation. Of course, Soviet reaction sharply criticized this interpretation, as did many U.S. allies.

4. Permissive Interpretation

This interpretation essentially arrives at the same conclusion as the broad interpretation, but under different auspices. This interpretation was actually drawn up early in the Reagan Administration, before the broad interpretation. Both were used to further the Strategic Defense Initiative (SDI) development and to seek a "legal" basis to shield it from attacks by critics.

The permissive interpretation says that the treaty allows for the development and testing of components of an ABM system if they do not have the full power or accuracy needed to be effectively used in such a defensive system. Therefore, these components could not be said to be used "in an ABM mode".

Viewed another way, the permissive interpretation proponents do agree that the treaty does apply to both traditional <u>and</u> new technologies. However, they also believed that none of the new technology "devices" then under development and being tested under SDI programs constituted a "component" as prohibited by Article V of the treaty. This was because such a device would have to satisfy a myriad of technical specifications and performance capabilities in order to be called a component. Since these "devices" were said not satisfy these criteria, they could not be called "components" and were therefore not subject to testing restrictions under the treaty. [Grabbe, 1991]

5. Current Trend

The current U.S. Administration does not deal with any of the legerdemain discussed above. They seek to reach an agreement with Russia based upon technical principles based upon the differences between TMD and NMD (or Strategic) systems. This difference is manifested in the closing velocities between a ballistic missile and its

interceptor, and upon the maximum range the ballistic missile is attempting to achieve. The initial agreement states that "missile systems traveling at speeds lower than 3 km/sec are exempt from the treaty as long as they are not tested against missiles traveling at speeds greater than 5 km/sec or distances greater than 3500 km." [Foote, 1996]

6. Conclusion

If one disregards the historical context and the common understandings used to reach an agreement that the 1972 ABM Treaty provided, then one could unabashedly justify either approach used for either of the Reagan Administration interpretations. Indeed, there is some merit to the permissive interpretation with respect to components. In retrospect, perhaps history will better remember that these attempts were correct from the viewpoint that "the end justifies the means." However, perhaps the U.S. should have more correctly executed Article XV of the treaty and withdrawn from it entirely.

In the current case, the attempt is being made to define what constitutes an ABM system as defined in the treaty (i.e. to counter strategic missiles) and what constitutes a TMD system. Clearly, there is no provision in the treaty for such differentiation. Though Article XIII and XIV of the treaty allow for amending the treaty due to such issues as changing circumstances, any such action without the advice and consent of the Senate would not stand when faced with Constitutional scrutiny.

D. SPACE WARFARE

"Mastery of Space is an important prerequisite for achieving victory in war."

- Dictionary of Basic Military Terms, USSR, 1965 [Lupton, 1988]

Given the above dictum, it might be difficult to imagine why the U.S. does not at present have a greater capability to conduct space warfare. Certainly one legacy in the American space odyssey is President Eisenhower's "Open Skies" policy and the effort to preserve space for peaceful purposes. However, the single-sided Soviet threat of yesterday is gone and has not been replaced. Or has it conceivably been replaced by the rest of the world? Certainly the development of Third World space capabilities, not to mention the

residual capabilities if the former Soviet Union (FSU), could threaten the U.S. and necessitate the need to counter them. Therefore, one must look at the measures in place that are responsible to counter such threats. Currently, this mission is assigned to the United States Space Command (USSPACECOM).

The USSPACECOM, established in 1985, is a unified (functional) command organized to consolidate military assets affecting U.S. space activities. As such, the USSPACECOM has four distinct missions to complete: *Space Forces Support, Space Force Enhancement, Space Force Application, and Space Force Control.*. USSPACECOM's area of responsibility (AOR) is the operational medium of space.

- **Space Forces Support**

These operations include all actions necessary to sustain spaceborne forces; launch, on-orbit command and control (C^2), tracking, and on-orbit servicing and recovery. On-orbit C^2 is achieved through a world-wide network of 28 ground stations, while launch sites are maintained at Cape Canaveral Air Station, FL, and Vandenburg Air force Base, CA.

- **Space Force Enhancement**

These missions provide direct support to air, land, and sea forces through the use of space systems. They improve the effectiveness of military operations by providing communications capability early warning, navigation, surveillance, and environmental monitoring (weather) satellites; This is achieved through a mix of military as well as commercial satellites.

- **Space Forces Application**

This will be accomplished through the future acquisition of ballistic missile defense systems. The Department of Defense (DOD) Ballistic Missile Defense Organization will provide those systems which will protect the forward deployed U.S. forces and its friends and allies from limited theater ballistic missile (TBM) strikes. Future systems may provide for ballistic missile defense of the American homeland. USSPACECOM will provide the

necessary space-based warning, surveillance and cueing to theater commanders to carry out TBM defense. Likewise, the same support is currently provided to the North American Defense Command (NORAD) for the protection of North America against ballistic missile attack.

- **Space Force Control**

These operations preserve U.S. ability to conduct space operations and divert, delay, disrupt, or destroy an adversary's space-based systems capability and terrestrial infrastructure. This will assure U.S. forces and systems access to and unimpeded operations in space, while denying the same to the enemy. These missions are accomplished through surveillance and counterspace operations. Surveillance is provided by the USSPACECOM's worldwide Space Surveillance Network (SSN) which can detect, track, identify, and catalog certain space objects in order to provide warning to U.S. space operations for the protection of space based assets. Counterspace operations are offensive and defensive operations conducted against an enemy's space forces (space or terrestrial) to gain and maintain the desired degree (disruption, degradation, denial, or destruction) of space superiority. This would include the use of anti-satellite (ASAT) weapons, though the U.S. does not currently posses such a system. [Mantz, 1995]

V. CONCLUSION

It should be apparent that space laws and policies have not been bounded by international space laws, but instead by national self-restraint on the part of the spacefaring nations. Even after 40 years of space exploration, man still follows a haphazard and incomplete collection of agreements that were written in the first half of this period of exploration. While technology advancements, applications, and studies of space have increased man's knowledge exponentially, little has been accomplished to ensure the responsible use of space. Much of this has been due to the desire on the part of space users to not lock themselves into a priori rules which could potentially restrict or delay their use of space. This has especially been true if one looks at the growing problem of space debris; it is probably only a matter of time before the costs of shielding or the need for on-orbit spares will decide for us that action is required.

Concerning delimitation, a nation's access to space has never been hampered or protested by another nation. A logical conclusion drawn is that this would form the basis of a customary law that will allow the flight of one nation's space vehicle through the sovereign airspace of another nation, but only while in transit to/from space. While no such flight occurs today (not even the U.S. Space Shuttle), future technology may well turn this probability into a reality. Some nations may surely object to such overflight regardless of whether the vehicle is coming or going to space. They will demand that the spacecraft obey aircraft laws while in foreign airspace. Though such possible events make for interesting discussion today, it is not to imperative that laws are needed now in order to prepare for such an eventuality.

Two points are clear. First, both spacefaring and non-spacefaring nations need to enact a new set of laws or agreements which are definitive and unambiguous. All of the treaties discussed contain many noble and well-intentioned articles, but there is an absence of descriptive definition of the key terms used throughout their passages. Because of this,

the supposed applicability to a given situation and any inferences or conclusions drawn can be forcefully and convincingly argued to the contrary. It seems that the hazy language used when drafting these documents attests to the lack of any real international agreement or a breakthrough in political/national ideology. Further, there exist no rules of enforcement nor a defined group who will referee pronounced "violations"; individual nations are left alone in their determination of a course of action.

The first of these treaties, the Outer Space Treaty, took over ten years of negotiation before an acceptable text was agreed upon. Consensus concerning new laws and agreements would be ideal, if it can be reached. However, the ever increasing use of and dependency on space activities in the world-body today dictates that action be taken before, rather than after, problems occur. Since the U.S. is the world leader in space, it is probably time for them to take the lead in the development and implementation of sound procedures for the use of space; this should be done unilaterally if necessary. While this could impose economic hardships on U.S. companies or appear to make the U.S. commercial space market less competitive on the world market, the use of subsidies could be used to negate such an effect. Of course, the sharing of U.S. technology with other nations would probably be required in order to attain optimum results and to gain international support.

The second point is that it is not in the best interests of the United States to abide by the provisions of a treaty or agreement when it becomes apparent that drastically changed world circumstances dictate otherwise. A prime example of this is the ABM Treaty. In the face of current world events, the U.S. has changed its warfighting doctrine, shrunk its military, and decreased its commitment overseas, yet it has clung to the tenets of this agreement in the belief that it is still relevant. It is not. While this may seem to be an obscure issue, one must only study the enormous effort being expended on ballistic missile defenses to realize that a new era in space warfare is just around the corner. Let us not forget to keep the closet clean.

APPENDIX A. HISTORY OF ON-ORBIT FRAGMENTATIONS

Common Name	International Designator	Catalog Number	Launch Date	Event Date	Cataloged Upon Breakup	Currently Tracked In Orbit	Apogee (km)	Perigee (km)	Incl. (°)	Probable Cause	Comments
TRANSIT 4A R/B	1961-OMI 3	118	29-Jun-61	29-Jun-61	298	200	995	880	66.8	PROPULSION	ABLESTAR STAGE
SPUTNIK 29	1962-B IOT 1	443	24-Oct-62	29-Oct-62	24	0	260	200	65.1	PROPULSION	SL-6 FINAL STAGE
ATLAS CENTAUR 2	1963-47A	694	27-Nov-63	27-Nov-63	19	9	1785	475	30.3	PROPULSION	CENTAUR STAGE
COSMOS 50	1964-70A	919	28-Oct-64	05-Nov-64	96	0	220	175	51.2	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 57	1965-12A	1093	22-Feb-65	22-Feb-65	167	0	425	165	64.8	COMMAND	INADVERTENT DESTRUCTION
COSMOS 61-63 R/B	1965-20D	1270	15-Mar-65	15-Mar-65	147	22	1825	260	56.1	UNKNOWN	SL-8 FINAL STAGE
OV2-1/LCS 2 R/B	1965-82B	1640	15-Oct-65	15-Oct-65	470	55	790	710	32.2	PROPULSION	TITAN 3C-4 TRANSTAGE
OPS 3031	1966-12C	2015	15-Feb-66	15-Feb-66	38	0	270	150	96.5	UNKNOWN	
GEMINI 9 ATDA R/B	1966-46B	2188	01-Jun-66	Mid-Jun-66	51	0	275	240	28.8	UNKNOWN	ATLAS CORE STAGE
AS-203	1966-59A	2289	05-Jul-66	05-Jul-66	34	0	215	185	32.0	DELIBERATE	SATURN SIVB STAGE
USSR UNKNOWN 1	1966-88A	2437	17-Sep-66	17-Sep-66	53	0	855	140	49.6	UNKNOWN	
USSR UNKNOWN 2	1966-101A	2536	02-Nov-66	02-Nov-66	41	0	885	145	49.6	UNKNOWN	
APOLLO 6 R/B (S4B)	1968-25B	3171	04-Apr-68	13-Apr-68	16	0	360	200	32.6	PROPULSION	SATURN SIVB STAGE
COSMOS 249	1968-91A	3504	20-Oct-68	20-Oct-68	109	55	2165	490	62.3	DELIBERATE	TEST
COSMOS 248	1968-90A	3503	19-Oct-68	01-Nov-68	5	0	545	475	62.2	DELIBERATE	TEST
COSMOS 252	1968-97A	3530	01-Nov-68	01-Nov-68	140	53	2140	535	62.3	DELIBERATE	TEST
METEOR 1-1 R/B	1969-29B	3836	26-Mar-69	28-Mar-69	37	0	850	460	81.2	UNKNOWN	SL-3 FINAL STAGE

Common Name	International Designator	Catalog Number	Launch Date	Event Date	Cataloged Upon Breakup	Currently Tracked In Orbit	Apogee (km)	Perigee (km)	Incl. (°)	Probable Cause	Comments
INTELSAT 3 F-5 R/B	1969-64B	4052	26-Jul-69	26-Jul-69	26	1	5445	270	30.4	PROPULSION	TE 364-4 STAGE
OPS 7613 R/B	1969-82AB	4159	30-Sep-69	04-Oct-69	260	97	940	905	70.0	UNKNOWN	AGENDA D STAGE
NIMBUS 4 R/B	1970-25C	4367	08-Apr-70	17-Oct-70	372	278	1085	1065	99.9	UNKNOWN	AGENDA D STAGE
		4601	23-Jan-85							UNKNOWN	
		4649	17-Dec-85							UNKNOWN	3 ADDITIONAL OBJECTS
		4610	02-Sep-86							UNKNOWN	2 ADDITIONAL OBJECTS
		4601	23-Dec-91							UNKNOWN	5 ADDITIONAL OBJECTS
COSMOS 374	1970-89A	4594	23-Oct-70	23-Oct-70	102	36	2130	530	62.9	DELIBERATE	TEST
COSMOS 375	1970-91A	4598	30-Oct-70	30-Oct-70	47	27	2100	525	62.8	DELIBERATE	TEST
COSMOS 397	1971-15A	4964	25-Feb-71	25-Feb-71	116	59	2200	575	65.8	DELIBERATE	TEST
COSMOS 462	1971-106A	5646	03-Dec-71	03-Dec-71	25	0	1800	230	65.7	DELIBERATE	TEST
SALYUT 2 R/B	1973-17B	6399	03-Apr-73	03-Apr-73	25	0	245	195	51.5	PROPULSION	SL-13 FINAL STAGE
COSMOS 554	1973-21A	6432	19-Apr-73	06-May-73	195	0	350	170	72.9	DELIBERATE	PAYLOAD RECOVERY FAILURE
NOAA 3 R/B	1973-86B	6921	06-Nov-73	28-Dec-73	197	180	1510	1500	102.1	PROPULSION	DELTA SECOND STAGE
COSMOS 699	1974-103A	7587	24-Dec-74	17-Apr-75	50	0	445	425	65.0	DELIBERATE	FIRST OF COSMOS 699 CLASS
			02-Aug-75				440	415	65.0	DELIBERATE	
LANDSAT 1 R/B	1972-58B	6127	23-Jul-72	22-May-75	226	52	910	635	98.3	PROPULSION	DELTA SECOND STAGE
PAGEOS	1966-56A	2253	24-Jun-66	12-Jul-75	79	3	5170	3200	85.3	UNKNOWN	NUMEROUS OTHER EVENTS
			20-Jan-76				5425	2935	85.1	UNKNOWN	
			10-Sep-76							UNKNOWN	
			MID-Jun-78							UNKNOWN	
			MID-Sep-84							UNKNOWN	
			MID-Dec-85							UNKNOWN	
NOAA 4 R/B	1974-89D	7532	15-Nov-74	20-Aug-75	148	129	1460	1445	101.7	PROPULSION	DELTA SECOND STAGE
COSMOS 758	1975-80A	8191	05-Sep-75	06-Sep-75	76	0	325	175	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 777	1975-102A	8416	29-Oct-75	25-Jan-76	62	0	440	430	65.0	DELIBERATE	COSMOS 699 CLASS

Common Name	International Designator	Catalog Number	Launch Date	Event Date	Cataloged Upon Breakup	Currently Tracked In Orbit	Apogee (km)	Perigee (km)	Incl. (°)	Probable Cause	Comments
LANDSAT 2 R/B	1975-04B	7616	22-Jan-75 19-Jun-76	09-Feb-76	207	39	915 910	740 745	97.8 97.7	UNKNOWN PROPULSION	DELTA SECOND STAGE
COSMOS 844	1976-72A	9046	22-Jul-76	25-Jul-76	248	0	355	170	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 886	1976-126A	9634	27-Dec-76	27-Dec-76	76	63	2295	595	65.8	DELIBERATE	TEST
COSMOS 862	1976-105A	9495	22-Oct-76	15-Mar-77	11	11	39645	765	63.2	PROPULSION	FIRST OF COSMOS 862 CLASS
COSMOS 838	1976-63A	8932	02-Jul-76	17-May-77	40	0	445	415	65.1	DELIBERATE	COSMOS 699 CLASS
HIMAWARI 1 R/B	1977-65B	10144	14-Jul-77	14-Jul-77	169	79	2025	535	29.0	PROPULSION	DELTA SECOND STAGE
COSMOS 839	1976-67A	9011	08-Jul-76	29-Sep-77	70	67	2100	980	65.9	UNKNOWN	FIRST OF COSMOS 839 CLASS
COSMOS 931	1977-68A	10150	20-Jul-77	24-Oct-77	6	5	39665	680	62.9	PROPULSION	COSMOS 862 CLASS
COSMOS 970	1977-121A	10531	21-Dec-77	21-Dec-77	70	67	1140	945	65.8	DELIBERATE	TEST
NOAA 5 R/B	1976-77B	9063	29-Jul-76	24-Dec-77	159	154	1520	1505	102.0	PROPULSION	DELTA SECOND STAGE
COSMOS 903	1977-27A	9911	11-Apr-77	08-Jun-78	2	2	39035	1325	63.2	PROPULSION	COSMOS 862 CLASS
EKRAN 2	1977-92A	10365	20-Sep-77	25-Jun-78	1	1	35798	35786	0.1	ELECTRICAL MALFUNCTION	NI H2 BATTERY
COSMOS 1030	1978-83A	11015	06-Sep-78	10-Oct-78	4	4	39760	665	62.8	PROPULSION	COSMOS 862 CLASS
COSMOS 880	1976-120A	9601	09-Dec-76	27-Nov-78	49	2	620	550	65.8	UNKNOWN	COSMOS 839 CLASS
COSMOS 917	1977-47A	10059	16-Jun-77	30-Mar-79	1	1	38725	1645	62.9	PROPULSION	COSMOS 862 CLASS
COSMOS 1124	1979-77A	11509	28-Aug-79	09-Sep-79	5	5	39795	570	63.0	PROPULSION	COSMOS 862 CLASS
COSMOS 1094	1979-33A	11333	18-Apr-79	17-Sep-79	1	0	405	380	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1109	1979-58A	11417	27-Jun-79	Mid-Feb-80	6	6	39425	960	63.3	PROPULSION	COSMOS 862 CLASS
CAT R/B	1979-104B	11659	24-Dec-79	Apr-80	1	0	33140	180	17.9	UNKNOWN	ARIANE 1 FINAL STAGE

Common Name	International Designator	Catalog Number	Launch Date	Event Date	Cataloged Upon Breakup	Currently Tracked In Orbit	Apogee (km)	Perigee (km)	Incl. (°)	Probable Cause	Comments
COSMOS 1174	1980-30A	11765	18-Apr-80	18-Apr-80	46	11	1660	380	66.1	DELIBERATE	TEST
LANDSAT 3 R/B	1978-26C	10704	05-Mar-78	27-Jan-81	209	147	910	900	98.8	PROPULSION	DELTA SECOND STAGE
COSMOS 1261	1981-31A	12376	31-Mar-81	APR/May-81	4	4	39765	610	63.0	PROPULSION	COSMOS 862 CLASS
COSMOS 1191	1980-57A	11871	02-Jul-80	14-May-81	2	2	39255	1110	62.6	PROPULSION	COSMOS 862 CLASS
COSMOS 1167	1980-21A	11729	14-Mar-80	15-Jul-81	12	0	450	355	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1275	1981-53A	12504	04-Jun-81	24-Jul-81	306	275	1015	960	83.0	UNKNOWN	POSSIBLE IMPACT?
COSMOS 1305 R/B	1981-88F	12827	11-Sep-81	11-Sep-81	3	3	13795	605	62.8	POPULSION	SL-6 FINAL STAGE
COSMOS 1247	1981-16A	12303	19-Feb-81	20-Oct-81	4	4	39390	970	63.0	PROPULSION	COSMOS 862 CLASS
COSMOS 1285	1981-71A	12627	04-Aug-81	21-Nov-81	3	3	40100	720	63.1	PROPULSION	COSMOS 862 CLASS
NIMBUS 7 R/B	1978-98B	11081	24-Oct-78	26-Dec-81	1	1	955	935	99.3	UNKNOWN	DELTA SECOND STAGE
COSMOS 1260	1981-28A	12364	20-Mar-81	08-May-82	68	1	750	450	65.0	DELIBERATE	COSMOS 699 CLASS
			10-Aug-82				750	445	65.0	DELIBERATE	
COSMOS 1220	1980-89A	12054	04-Nov-80	20-Jun-82	78	1	885	570	65.0	DELIBERATE	COSMOS 699 CLASS
			25-Aug-82				885	565	65.0	DELIBERATE	
COSMOS 1306	1981-89A	12828	14-Sep-81	12-Jul-82	8	0	405	380	64.9	DELIBERATE	COSMOS 699 CLASS
			18-Sep-82				370	370	64.9	DELIBERATE	
COSMOS 1286	1981-72A	12631	04-Aug-81	29-Sep-82	2	0	325	300	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1423 R/B	1982-115E	13696	08-Dec-82	08-Dec-82	29	0	427	235	62.9	PROPULSION	SL-6 FINAL STAGE
COSMOS 1481	1983-70A	14182	08-Jul-83	09-Jul-83	3	3	39225	625	62.9	PROPULSION	COSMOS 862 CLASS
COSMOS 1355	1982-38A	13150	29-Apr-82	08-Aug-83	29	0	395	360	65.1	DELIBERATE	COSMOS 699 CLASS
			01-Feb-84				320	305	65.0	DELIBERATE	
			20-Feb-84				290	270	65.0	DELIBERATE	
COSMOS 1456	1983-38A	14034	25-Apr-83	13-Aug-83	4	4	39630	730	63.3	PROPULSION	COSMOS 862 CLASS
COSMOS 1405	1982-88A	13508	04-Sep-82	20-Dec-83	32	0	340	310	65.0	DELIBERATE	COSMOS 699 CLASS

Common Name	International Designator	Catalog Number	Launch Date	Event Date	Cataloged Upon Breakup	Currently Tracked In Orbit	Apogee (km)	Perigee (km)	Incl. (°)	Probable Cause	Comments
COSMOS 1317	1981-108A	12933	31-Oct-81	LATE-Jan-84	4	4	39055	1315	62.8	PROPULSION	COSMOS 862 CLASS
WESTAR 6 R/B	1984-11F	14694	03-Feb-84	03-Feb-84	14	1	310	305	28.5	PROPULSION	PAM-D UPPER STAGE
PALAPA B2 R/B	1984-11E	14693	03-Feb-84	06-Feb-84	3	1	285	275	28.5	PROPULSION	PAM-D UPPER STAGE
ASTRON DEB	1983-20B	13902	23-Mar-83	03-Sep-84	1	0	1230	220	51.5	PROPULSION	SL-12 FINAL STAGE DEBRIS
COSMOS 1461	1983-44A	14064	07-May-83 13-May-85	11-Mar-83	158	3	890 885	570 570	65.0 65.0	DELIBERATE DELIBERATE	COSMOS 699 CLASS
COSMOS 1654	1985-39A	15734	23-May-85	21-Jun-85	18	0	300	185	64.9	DELIBERATE	PAYLOAD RECOVERY FAILURE
P-78 (SOLWIND)	1979-17A	11278	24-Feb-79	13-Sep-85	285	9	545	515	97.6	DELIBERATE	TEST
COSMOS 1375	1982-55A	13259	06-Jun-82	21-Oct-85	58	57	1000	990	65.8	UNKNOWN	COSMOS 839 CLASS
COSMOS 1691	1985-94B	16139	09-Oct-85	22-Nov-85	14	11	1415	1410	82.6	ELECTRICAL	NI H2 BATTERY MALFUNCTION
NOAA 8	1983-22A	13923	28-Mar-83	30-Dec-85	7	1	830	805	98.6	ELECTRICAL	BATTERY MALFUNCTION
COSMOS 1588	1984-83A	15167	07-Aug-84	23-Feb-86	45	0	440	410	65.0	DELIBERATE	COSMOS 699 CLASS
USA 19	1986-69A	16937	05-Sep-86	05-Sep-86	13	0	745	210	39.1	DELIBERATE	TEST (SEE ALSO USA 19 R/B)
USA 19 R/B	1986-69B	16938	05-Sep-86	05-Sep-86	5	0	610	220	22.8	DELIBERATE	TEST (SEE ALSO USA 19)
SPOT 1 R/B	1986-19C	16615	22-Feb-86	13-Nov-86	489	59	835	805	98.7	UNKNOWN	ARIANE 1 FINAL STAGE
COSMOS 1278	1981-58A	12547	19-Jun-81	Early-Dec-86	2	2	37690	2665	67.1	PROPULSION	COSMOS 862 CLASS
COSMOS 1682	1985-82A	16054	19-Sep-85	18-Dec-86	23	0	475	385	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1813	1987-04A	17297	15-Jan-87	29-Jan-87	194	0	415	360	72.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1866	1987-59A	18184	09-Jul-87	26-Jul-87	9	0	255	155	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
AUSSAT/ECS R/B	1987-78C	18352	16-Sep-87	Mid-Sep-87	2	1	36515	245	6.9	UNKNOWN	ARIANE 3 FINAL STAGE
COSMOS 1769	1986-59A	16895	04-Aug-86	21-Sep-87	4	0	445	310	65.0	DELIBERATE	COSMOS 699 CLASS

Common Name	International Designator	Catalog Number	Launch Date	Event Date	Cataloged Upon Breakup	Currently Tracked In Orbit	Apogee (km)	Perigee (km)	Incl. (°)	Probable Cause	Comments
COSMOS 1646	1985-30A	15653	18-Apr-85	20-Nov-87	24	0	410	385	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1823	1987-20A	17535	20-Feb-87	17-Dec-87	110	46	1525	1480	73.6	ELECTRICAL	NI H2 BATTERY MALFUNCTION
COSMOS 1656 DEB	1985-42E	15773	30-May-85	05-Jan-88	6	6	860	810	66.6	PROPULSION	SL-12 FINAL STAGE DEBRIS
COSMOS 1906	1987-108A	18713	26-Dec-87	31-Jan-88	37	0	265	245	82.6	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1916	1988-07A	18823	03-Feb-88	27-Feb-88	1	0	230	150	64.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1045 R/B	1978-100D	11087	26-Oct-78	09-May-88	45	42	1705	1685	82.6	UNKNOWN	SL-14 FINAL STAGE
COSMOS 2030	1989-54A	20124	12-Jul-89	28-Jul-89	1	0	215	150	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 2031	1989-56A	20136	18-Jul-89	31-Aug-89	9	0	365	240	50.5	DELIBERATE	PAYLOAD RECOVERY FAILURE
FENGYUN 1-2 R/B	1990-81D	20791	03-Sep-90	04-Oct-90	73	69	895	880	98.9	UNKNOWN	CZ-4A FINAL STAGE
COSMOS 2101	1990-87A	20828	01-Oct-90	30-Nov-90	4	0	280	195	64.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
USA 68	1990-105A	20978	01-Dec-90	01-Dec-90	29	5	850	610	98.9	PROPULSION	TE-M-364-15-UPPER STAGE
COSMOS 1519-21 DEB	1983-127H	14608	29-Dec-83	04-Feb-91	5	4	18805	340	51.9	PROPULSION	SL-12 FINAL STAGE DEBRIS
COSMOS 2125-32 R/B	1991-09J	21108	12-Feb-91	05-Mar-91	73	73	1725	1460	74.0	UNKNOWN	SL-8 FINAL STAGE; UP TO 9 SEPARATE EVENTS
NIMBUS 6 R/B	1975-52B	7946	12-Jun-75	01-May-91	236	190	1103	1093	99.6	PROPULSION	DELTA SECOND STAGE
COSMOS 2163	1991-71A	21741	09-Oct-91	06-Dec-91	1	0	259	187	64.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1710-2 DEB	1985-118L	16446	24-Dec-85	29-Dec-91	2	2	18886	654	65.3	PROPULSION	SL-12 FINAL STAGE DEBRIS
OV2-5 R/B	1968-81E	3432	26-Sep-68	21-Feb-92	1	1	35812	35102	11.9	UNKNOWN	
COSMOS 2045 DEB	1989-101E	20399	27-Dec-89	Jul-92 (?)	2	2	27651	344	47.1	PROPULSION	SL-12 FINAL STAGE DEBRIS
COSMOS 1603 DEB	1984-106F	15338	28-Sep-84	05-Sep-92	22	1	845	836	66.6	PROPULSION	SL-12 FINAL STAGE DEBRIS
GORIZONT 17 DEB	1989-04E	19771	26-Jan-89	17/8-Dec-92	1	1	17577	197	46.7	PROPULSION	SL-12 FINAL STAGE DEBRIS

Common Name	International Designator	Catalog Number	Launch Date	Event Date	Cataloged Upon Breakup	Currently Tracked In Orbit	Apogee (km)	Perigee (km)	Incl. (°)	Probable Cause	Comments
COSMOS 2227 R/B	1992-93B	22285	25-Dec-92	26-Dec-92	209	208	855	847	71.0	UNKNOWN	SL-16 FINAL STAGE
			30-Dec-92				855	847	71.0	UNKNOWN	
GORIZONT 18 DEB	1989-52F	20116	05-Jul-89	12-Jan-93	1	1	36747	258	46.8	PROPULSION	SL-12 FINAL STAGE DEBRIS
COSMOS 2225	1992-91A	22280	22-Dec-92	18-Feb-93	6	0	279	227	64.9	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 2237 R/B	1993-16B	22566	26-MAR-93	28-MAR-93	27	27	850	841	71.0	UNKNOWN	SL-16 FINAL STAGE
COSMOS 2243 R/B	1993-28B	22642	27-APR-93	27-APR-93	1	0	225	181	70.4	UNKNOWN	SL-4 FINAL STAGE (PAYLOAD?)
COSMOS 1484	1983-75A	14207	24-JUL-83	18-OCT-93	33	31	593	545	97.5	UNKNOWN	
COSMOS 2262	1993-57A	22789	07-SEP-93	18-DEC-93	1	0	316	180	64.9	DELIBERATE	PAYLOAD RECOVERY FAILURE
CLEMINTINE R/B	1994-04B	22974	25-JAN-94	07-FEB-94	0	0	297	240	67.0	UNKNOWN	
COSMOS 2133	1991-10D	21114	14-FEB-93	07-MAY-94	?	?	21805	225	46.6	UNKNOWN	SCZ MOTOR
ASTRA/MOP R/B (1)	1991-15C	21141	2-MAR-91	27-APR-94	3	3	28819	254	6.6	UNKNOWN	
COSMOS 2133 DEB	1991-010D	21114	12-FEB-91	7-MAY-94	1	1	21806	225	46.6	PROPULSION	SL-12 AUX MOTOR
COSMOSS 2204-06 DEB	1992-047H	22067	30-JUL-92	8-NOV-94	0	0	19033	479	64.6	PROPULSION	SL-12 AUX MOTOR
RS-15 R/B	1994-085B	23440	26-DEC-94	26-DEC-94	21	21	2199	1882	64.8	UNKNOWN	ROKOT FINAL STAGE
H-II R/B	1994-056B	23231	28-AUG-94	31-MAR-95	0	0	24209	129	28.6	UNKNOWN	FIRST JAPANESE R/B BREAKUP
ELEKTRO DEB	1994-069E	23338	31-OCT-94	11-MAY-95	0	0	35467	154	46.9	PROPULSION	SL-12 AUX MOTOR

APPENDIX B. TREATY ON PRINCIPLES GOVERNING THE ACTIVITIES OF STATES IN THE EXPLORATION AND USE OF OUTER SPACE, INCLUDING THE MOON AND OTHER CELESTIAL BODIES (OUTER SPACE TREATY)

January 27, 1967

The States Parties to this treaty,

Inspired by the great prospects opening up before mankind as a result of man's entry into outer space,

Recognizing the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes,

Believing that the exploration and use of outer space should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development,

Desiring to contribute to broad international co-operation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful purposes,

Believing that such co-operation will contribute to the development of mutual understanding and to the strengthening of friendly relations between States and peoples,

Recalling resolution 1962 (XVIII), entitled "Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space," which was adopted unanimously by the United Nations General Assembly on 13 December 1963,

Recalling resolution 1884 (XVIII), calling upon States to refrain from placing in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction or from installing such weapons on celestial bodies, which was adopted unanimously by the United Nations General Assembly on 17 October 1963,

Taking account of United Nations General Assembly resolution 110 (II) of 3 November 1947, which condemned propaganda designed or likely to provoke or encourage any threat to the peace, breach of the peace or act of aggression, and considering that the aforementioned resolution is applicable to outer space,

Convinced that a Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, will further the Purposes and Principles of the Charter of the United Nations,

Have agreed on the following:

Article I

The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.

Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.

Article II

Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.

Article III

States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international co-operation and understanding.

Article IV

States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruc-

tion, install such weapons on celestial bodies or station such weapons in outer space in any other manner.

The moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the moon and other celestial bodies shall also not be prohibited.

Article V

States Parties to the Treaty shall regard astronauts as envoys of mankind in outer space and shall render to them all possible assistance in the event of accident, distress, or emergency landing on the territory of another State Party or on the high seas. When astronauts make such a landing, they shall be safely and promptly returned to the State of registry of their space vehicle.

In carrying on activities in outer space and on celestial bodies, the astronauts of one State Party shall render all possible assistance to the astronauts of other States Parties.

States Parties to the Treaty shall immediately inform the other States Parties to the Treaty or the Secretary-General of the United Nations of any phenomena they discover in outer space, including the moon and other celestial bodies, which could constitute a danger to the life or health of astronauts.

Article VI

States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried on in outer space, including the moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.

Article VII

Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the moon and other celestial bodies, and each

State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the moon and other celestial bodies.

Article VIII

A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body. Ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their component parts, is not affected by their presence in outer space or on a celestial body or by their return to Earth. Such objects or component parts found beyond the limits of the State Party to the Treaty on whose registry they are carried shall be returned to that State Party, which shall, upon request, furnish identifying data prior to their return.

Article IX

In the exploration and use of outer space, including the moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the moon and other celestial bodies, may request consultation concerning the activity or experiment.

Article X

In order to promote international co-operation in the exploration and use of outer space, including the moon and other celestial bodies, in conformity with

the purposes of this Treaty, the States Parties to the Treaty shall consider on a basis of equality any requests by other States Parties to the Treaty to be afforded an opportunity to observe the flight of space objects launched by those states.

The nature of such an opportunity for observation and the conditions under which it could be afforded shall be determined by agreement between the States concerned.

Article XI

In order to promote international co-operation in the peaceful exploration and use of outer space, States Parties to the Treaty conducting activities in outer space, including the moon and other celestial bodies, agree to inform the Secretary-General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities. On receiving the said information, the Secretary-General of the United Nations should be prepared to disseminate it immediately and effectively.

Article XII

All stations, installations, equipment and space vehicles on the moon and other celestial bodies shall be open to representatives of other States Parties to the Treaty on a basis of reciprocity. Such representatives shall give reasonable advance notice of a projected visit, in order that appropriate consultations may be held and that maximum precautions may be taken to assure safety and to avoid interference with normal operations in the facility to be visited.

Article XIII

The provisions of this Treaty shall apply to the activities of States Parties to the Treaty in the exploration and use of outer space, including the moon and other celestial bodies, whether such activities are carried on by a single State Party to the Treaty or jointly with other States, including cases where they are carried on within the framework of international inter-governmental organizations.

Any practical questions arising in connection with activities carried on by international inter-governmental organizations in the exploration and use of outer space, including the moon and other celestial bodies, shall be resolved by the States Parties to the Treaty either with the appropriate international organization or with one or more States members of that international organization, which are parties to this Treaty.

Article XIV

1. This Treaty shall be open to all States for signature. Any State which does not sign this Treaty before its entry into force in accordance with paragraph 3 of this article may accede to it at any time.

2. This Treaty shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland and the Union of Soviet Socialist Republics, which are hereby designated the Depositary Governments.

3. This treaty shall enter into force upon the deposit of instruments of ratification by five Governments including the Governments designated as Depositary Governments under this Treaty.

4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Treaty, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification of and accession to this treaty, the date of its entry into force and other notices.

6. This Treaty shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

Article XV

Any State Party to the Treaty may propose amendments to this Treaty. Amendments shall enter into force for each State Party to the Treaty accepting the amendments upon their acceptance by a majority of the States Parties to the Treaty and thereafter for each remaining State Party to the Treaty on the date of acceptance by it.

Article XVI

Any State Party to the Treaty may give notice of its withdrawal from the Treaty one year after its entry into force by written notification to the Depositary Governments. Such withdrawal shall take effect one year from the date of receipt of this notification.

Article XVII

This Treaty, of which the English, Russian, French, Spanish and Chinese texts are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Treaty shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding States.

APPENDIX C. AGREEMENT ON RESCUE OF ASTRONAUTS, THE RETURN OF ASTRONAUTS, AND THE RETURN OF OBJECTS LAUNCHED INTO OUTER SPACE (RESCUE AGREEMENT)

April 22, 1968

The Contracting Parties,

Noting the great importance of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, which calls for the rendering of all possible assistance to astronauts in the event of accident, distress or emergency landing, the prompt and safe return of astronauts, and the return of objects launched into outer space,

Desiring to develop and give further concrete expression to these duties,

Wishing to promote international co-operation in the peaceful exploration and use of outer space,

Prompted by sentiments of humanity,

Have agreed on the following:

Article 1

Each Contracting Party which receives information or discovers that the personnel of a spacecraft have suffered accident or are experiencing conditions of distress or have made an emergency or unintended landing in territory under its jurisdiction or on the high seas or in any other place not under the jurisdiction of any State shall immediately:

(a) Notify the launching authority or, if it cannot identify and immediately communicate with the launching authority, immediately make a public announcement by all appropriate means of communication at its disposal;

(b) Notify the Secretary-General of the United Nations, who should disseminate the information without delay by all appropriate means of communication at his disposal.

Article 2

If, owing to accident, distress, emergency or unintended landing, the personnel of a spacecraft land in territory under the jurisdiction of a Contracting Party, it shall immediately take all possible steps to rescue them and render them all necessary assistance. It shall inform the launching authority and also the Secretary-General of the United Nations of the steps it is taking and of their progress. If assistance by the launching authority would help to effect a prompt rescue or would contribute substantially to the effectiveness of search and rescue operations, the launching authority shall co-operate with the Contracting Party with a view to the effective conduct of search and rescue operations. Such operations shall be subject to the direction and control of the Contracting Party, which shall act in close and continuing consultation with the launching authority.

Article 3

If information is received or it is discovered that the personnel of a spacecraft have alighted on the high seas or in any other place not under the jurisdiction of any State, those Contracting Parties which are in a position to do so shall, if necessary, extend assistance in search and rescue operations for such personnel to assure their speedy rescue. They shall inform the launching authority and the Secretary-General of the United Nations of the steps they are taking and of their progress.

Article 4

If, owing to accident, distress, emergency, or unintended landing, the personnel of a spacecraft land in territory under the jurisdiction of a Contracting Party or have been found on the high seas or in any other place not under the jurisdiction of any State, they shall be safely and promptly returned to representatives of the launching authority.

Article 5

1. Each Contracting Party, which receives information or discovers that a space object or its component parts has returned to Earth in territory under its jurisdiction or on the high seas or in any other place not under the jurisdiction of any State, shall notify the launching authority and the Secretary-General of the United Nations.

2. Each Contracting Party having jurisdiction over the territory on which a space object or its component parts has been discovered shall, upon the request of the launching authority and with assistance from that authority if requested, take such steps as it finds practicable to recover the object or component parts.

3. Upon request of the launching authority, objects launched into outer space or their component parts found beyond the territorial limits of the launching authority shall be returned to or held at the disposal of representatives of the launching authority, which shall, upon request, furnish identifying data prior to their return.

4. Notwithstanding paragraphs 2 and 3 of this article, a Contracting Party which has reason to believe that a space object or its component parts discovered in territory under its jurisdiction, or recovered by it elsewhere, is of a hazardous or deleterious nature may so notify the launching authority, which shall immediately take effective steps, under the direction and control of the said Contracting Party, to eliminate possible danger of harm.

5. Expenses incurred in fulfilling obligations to recover and return a space object or its component parts under paragraphs 2 and 3 of this article shall be borne by the launching authority.

Article 6

For the purposes of this Agreement, the term "launching authority" shall refer to the State responsible for launching, or where an international inter-governmental organization is responsible for launching, that organization, provided that that organization declares its acceptance of the rights and obligations provided for in this Agreement and a majority of the States members of that organization are Contracting Parties to this agreement and to the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

Article 7

1. This Agreement shall be open to all States for signature. Any State which does not sign this Agreement before its entry into force in accordance with paragraph 3 of this article may accede to it at any time.

2. This Agreement shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland and the Union of Soviet Socialist Republics, which are hereby designated the Depositary Governments.

3. This Agreement shall enter into force upon the deposit of instruments of ratification by five Governments including the Governments designated as Depositary Governments under this Agreement.

4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Agreement, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification of and accession to this Agreement, the date of its entry into force and other notices.

6. This Agreement shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

Article 8

Any State Party to the Agreement may propose amendments to this Agreement. Amendments shall enter into force for each State Party to the Agreement accepting the amendments upon their acceptance by a majority of the States Parties to the Agreement and thereafter for each remaining State Party to the Agreement on the date of acceptance by it.

Article 9

Any State Party to the Agreement may give notice of its withdrawal from the Agreement one year after its entry into force by written notification to the Depositary Governments. Such withdrawal shall take effect one year from the date of receipt of this notification.

Article 10

This Agreement, of which the English, Russian, French, Spanish and Chinese texts are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Agreement shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding States.

APPENDIX D. CONVENTION ON INTERNATIONAL LIABILITY FOR DAMAGE CAUSED BY SPACE OBJECTS (LIABILITY CONVENTION)

March 29, 1972

The States Parties to this Convention,

Recognizing the common interest of all mankind in furthering the exploration and use of outer space for peaceful purposes,

Recalling the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies,

Taking into consideration that, notwithstanding the precautionary measures to be taken by States and international intergovernmental organizations involved in the launching of space objects, damage may on occasion be caused by such objects,

Recognizing the need to elaborate effective international rules and procedures concerning liability for damage caused by space objects and to ensure, in particular, the prompt payment under the terms of this Convention of a full and equitable measure of compensation to victims of such damage,

Believing that the establishment of such rules and procedures will contribute to the strengthening of international cooperation in the field of the exploration and use of outer space for peaceful purposes,

Have agreed on the following:

Article I

For the purposes of this Convention:

(a) The term "damage" means loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations;

(b) The term "launching" includes attempted launching;

(c) The term "launching State" means:

(i) A State which launches or procures the launching of a space object;

(ii) A State from whose territory or facility a space object is launched;

(d) The term "space object" includes component parts of a space object as well as its launch vehicle and parts thereof.

Article II

A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight.

Article III

In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible.

Article IV

1. In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching state, and of damage thereby being caused to a third State or to its natural or juridical persons, the first two States shall be jointly and severally liable to the third State, to the extent indicated by the following:

(a) If the damage has been caused to the third State on the surface of the earth or to aircraft in flight, their liability to the third State shall be absolute;

(b) If the damage has been caused to a space object of the third State or to persons or property on board that space object elsewhere than on the surface of the earth, their liability to the third State shall be based on the fault of either of the first two States or on the fault of persons for whom either is responsible.

2. In all cases of joint and several liability referred to in paragraph 1 of this article, the burden of compensation for the damage shall be apportioned be-

tween the first two States in accordance with the extent to which they were at fault; if the extent of the fault of each of these States cannot be established, the burden of compensation shall be apportioned equally between them. Such apportionment shall be without prejudice to the right of the third State to seek the entire compensation due under this Convention from any or all of the launching States which are jointly and severally liable.

Article V

1. Whenever two or more States jointly launch a space object, they shall be jointly and severally liable for any damage caused.

2. A launching State which has paid compensation for damage shall have the right to present a claim for indemnification to other participants in the joint launching. The participants in a joint launching may conclude agreements regarding the apportioning among themselves of the financial obligation in respect of which they are jointly and severally liable. Such agreements shall be without prejudice to the right of a State sustaining damage to seek the entire compensation due under this Convention from any or all of the launching States which are jointly and severally liable.

3. A State from whose territory or facility a space object is launched shall be regarded as a participant in a joint launching.

Article VI

1. Subject to the provisions of paragraph 2 of this article, exoneration from absolute liability shall be granted to the extent that a launching State establishes that the damage has resulted either wholly or partially from gross negligence or from an act or omission done with intent to cause damage on the part of a claimant State or of natural or juridical persons it represents.

2. No exoneration whatever shall be granted in cases where the damage has resulted from activities conducted by a launching State which are not in conformity with international law including, in particular, the Charter of the United Nations and the Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

Article VII

The provisions of this Convention shall not apply to damage caused by a space object of a launching State to:

(a) Nationals of that launching State;

(b) Foreign nationals during such time as they are participating in the operation of that space object from the time of its launching or at any stage thereafter until its descent, or during such time as they are in the immediate vicinity of a planned launching or recovery area as the result of an invitation by that launching State.

Article VIII

1. A State which suffers damage, or whose natural or juridical persons suffer damage, may present to a launching State a claim for compensation for such damage.

2. If the State of nationality has not presented a claim, another State may, in respect of damage sustained in its territory by any natural or juridical person, present a claim to a launching State.

3. If neither the State of nationality nor the State in whose territory the damage was sustained has presented a claim or notified its intention of presenting a claim, another State may, in respect of damage sustained by its permanent residents, present a claim to a launching State.

Article IX

A claim for compensation for damage shall be presented to a launching State through diplomatic channels. If a State does not maintain diplomatic relations with the launching State concerned, it may request another State to present its claim to that launching State or otherwise represent its interests under this Convention. It may also present its claim through the Secretary-General of the United Nations, provided the claimant State and the launching State are both Members of the United Nations.

Article X

1. A claim for compensation for damage may be presented to a launching State not later than one year following the date of the occurrence of the damage or the identification of the launching State which is liable.

2. If, however, a State does not know of the occurrence of the damage or has not been able to identify the launching State which is liable, it may present a claim within one year following the date on which it learned of the aforementioned facts; however, this period shall in no event exceed one year following the date on which the State could reasonably be expected to have learned of the facts through the exercise of due diligence.

3. The time-limits specified in paragraphs 1 and 2 of this article shall apply even if the full extent of the damage may not be known. In this event, however, the

claimant State shall be entitled to revise the claim and submit additional documentation after the expiration of such time-limits until one year after the full extent of the damage is known.

Article XI

1. Presentation of a claim to a launching State for compensation for damage under this Convention shall not require the prior exhaustion of any local remedies which may be available to a claimant State or to natural or juridical persons it represents.

2. Nothing in this Convention shall prevent a State, or natural or juridical persons it might represent, from pursuing a claim in the courts or administrative tribunals or agencies of a launching State. A State shall not, however, be entitled to present a claim under this Convention in respect of the same damage for which a claim is being pursued in the courts or administrative tribunals or agencies of a launching State or under another international agreement which is binding on the States concerned.

Article XII

The compensation which the launching State shall be liable to pay for damage under this Convention shall be determined in accordance with international law and the principles of justice and equity, in order to provide such reparation in respect of the damage as will restore the person, natural or juridical, State or international organization on whose behalf the claim is presented to the condition which would have existed if the damage had not occurred.

Article XIII

Unless the claimant State and the State from which compensation is due under this Convention agree on another form of compensation, the compensation shall be paid in the currency of the claimant State or, if that State so requests, in the currency of the State from which compensation is due.

Article XIV

If no settlement of a claim is arrived at through diplomatic negotiations as provided for in article IX, within one year from the date on which the claimant State notifies the launching State that it has submitted the documentation of its claim, the parties concerned shall establish a Claims Commission at the request of either party.

Article XV

1. The Claims Commission shall be composed of three members: one appointed by the claimant State, one appointed by the launching State and the third member, the Chairman, to be chosen by both parties jointly. Each party shall make its appointment within two months of the request for the establishment of the Claims Commission.

2. If no agreement is reached on the choice of the Chairman within four months of the request for the establishment of the Commission, either party may request the Secretary-General of the United Nations to appoint the Chairman within a further period of two months.

Article XVI

1. If one of the parties does not make its appointment within the stipulated period, the Chairman shall, at the request of the other Party, constitute a single-member Claims Commission.

2. Any vacancy which may arise in the Commission for whatever reason shall be filled by the same procedure adopted for the original appointment.

3. The Commission shall determine its own procedure.

4. The Commission shall determine the place or places where it shall sit and all other administrative matters.

5. Except in the case of decisions and awards by a single-member Commission, all decisions and awards of the Commission shall be by majority vote.

Article XVII

No increase in the membership of the Claims Commission shall take place by reason of two or more claimant States or launching States being joined in any one proceeding before the Commission. The claimant States so joined shall collectively appoint one member of the Commission in the same manner and subject to the same conditions as would be the case for a single claimant State. When two or more launching States are so joined, they shall collectively appoint one member of the Commission in the same way. If the claimant States or the launching States do not make the appointment within the stipulated period, the Chairman shall constitute a single-member Commission.

Article XVIII

The Claims Commission shall decide the merits of the claim for compensation and determine the amount of compensation payable, if any.

Article XIX

1. The Claims Commission shall act in accordance with the provisions of article XII.

2. The decision of the Commission shall be final and binding if the Parties have so agreed; otherwise the Commission shall render a final and recommendatory award, which the parties shall consider in good faith. The Commission shall state the reasons for its decision or award.

3. The Commission shall give its decision or award as promptly as possible and no later than one year from the date of its establishment, unless an extension of this period is found necessary by the Commission.

4. The Commission shall make its decision or award public. It shall deliver a certified copy of its decision or award to each of the parties and to the Secretary-General of the United Nations.

Article XX

The expenses in regard to the Claims Commission shall be borne equally by the parties, unless otherwise decided by the Commission.

Article XXI

If the damage caused by a space object presents a large-scale danger to human life or seriously interferes with the living conditions of the population or the functioning of vital centers, the States Parties, and in particular the launching State, shall examine the possibility of rendering appropriate and rapid assistance to the State which has suffered the damage, when it so requests. However, nothing in this article shall affect the rights or obligations of the States Parties under this Convention.

Article XXII

1. In this Convention, with the exception of articles XXIV to XXVII, references to States shall be deemed to apply to any international intergovernmental organization which conducts space activities if the organization declares its acceptance of the rights and obligations provided for in this Convention and if a majority of

the States members of the organization are States Parties to this Convention and to the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

2. States members of any such organization which are States Parties to this Convention shall take all appropriate steps to ensure that the organization makes a declaration in accordance with the preceding Paragraph.

3. If an international intergovernmental organization is liable for damage by virtue of the provisions of this Convention, that organization and those of its members which are States Parties to this Convention shall be jointly and severally liable; provided, however, that:

(a) Any claim for compensation in respect of such damage shall be first presented to the organization;

(b) Only where the organization has not paid, within a period of six months, any sum agreed or determined to be due as compensation for such damage, may the claimant State invoke the liability of the members which are States Parties to this Convention for the payment of that sum.

4. Any claim, pursuant to the provision of this Convention, for compensation in respect of damage caused to an organization which has made a declaration in accordance with paragraph 1 of this article shall be presented by a State member of the organization which is a State Party to this Convention.

Article XXIII

1. The provision of this Convention shall not affect other international agreements in force in so far as relations between the States Parties to such agreements are concerned.

2. No provision of this Convention shall prevent States from concluding international agreements reaffirming, supplementing or extending its provisions.

Article XXIV

1. This Convention shall be open to all States for signature. Any State which does not sign this Convention before its entry into force in accordance with paragraph 3 of this article may accede to it any time.

2. This Convention shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the United States of America, the United Kingdom of Great

Britain and Northern Ireland and the Union of Soviet Socialist Republics, which are hereby designated the Depositary Governments.

3. This Convention shall enter into force on the deposit of the fifth instrument of ratification.

4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Convention, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification of and accession to this Convention, the date of its entry into force and other notices.

6. This Convention shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

Article XXV

Any State Party to this Convention may propose amendments to this convention. Amendments shall enter into force for each State Party to the Convention accepting the amendments upon their acceptance by a majority of the States Parties to the Convention and thereafter for each remaining State Party to the Convention on the date of acceptance by it.

Article XXVI

Ten years after the entry into force of this Convention, the question of the review of this Convention shall be included in the provisional agenda of the United Nations General Assembly in order to consider, in the light of past application of the Convention, whether it requires revision. However, at any time after the Convention has been in force for five years, and at the request of one third of the States Parties to the Convention, and with the concurrence of the majority of the States Parties, a conference of the States Parties shall be convened to review this Convention.

Article XXVII

Any State Party to this Convention may give notice of its withdrawal from the Convention one year after its entry into force by written notification to the Depositary Governments. Such withdrawal shall take effect one year from the date of receipt of this notification.

Article XXVIII

This Convention, of which the English, Russian, French, Spanish and Chinese texts are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Convention shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding States.

APPENDIX E. CONVENTION ON REGISTRATION OF OBJECTS LAUNCHED INTO OUTER SPACE (REGISTRATION CONVENTION)

January 14, 1975

The States Parties to this Convention,

Recognizing the common interest of all mankind in furthering the exploration and use of outer space for peaceful purposes,

Recalling that the Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies of 27 January 1967 affirms that States shall bear international responsibility for their national activities in outer space and refers to the State on whose registry an object launched into outer space is carried.

Recalling also that the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space of 22 April 1968 provides that a launching authority shall, upon request, furnish identifying data prior to the return of an object it has launched into outer space found beyond the territorial limits of the launching authority.

Recalling further that the Convention on International Liability for Damage Caused by Space Objects of 29 March 1972 establishes international rules and procedures concerning the liability of launching States for damage caused by their space objects.

Desiring, in the light of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, to make provision for the national registration by launching States of space objects launched into outer space.

Desiring further that a central register of objects launched into outer space be established and maintained, on a mandatory basis, by the Secretary-General of the United Nations.

Desiring also to provide for States Parties additional means and procedures to assist in the identification of space objects.

Believing that a mandatory system of registering objects launched into outer space would, in particular, assist in their identification and would contribute to the application and development of international law governing the exploration and use of outer space,

Have agreed on the following:

Article I

For the purposes of this Convention:

(a) The term "launching State" means:

(i) A State which launches or procures the launching of a space object;

(ii) A State from whose territory or facility a space object is launched;

(b) The term "space object" includes component parts of a space object as well as its launch vehicle and parts thereof;

(c) The term "State of registry" means a launching State of whose registry a space object is carried in accordance with article II.

Article II

1. When a space object is launched into earth orbit or beyond, the launching State shall register the space object by means of an entry in an appropriate registry which it shall maintain. Each launching State shall inform the Secretary-General of the United Nations of the establishment of such a registry.

2. Where there are two or more launching States in respect of any such space object, they shall jointly determine which one of them shall register the object in accordance with paragraph 1 of this article, bearing in mind the provisions of article VIII of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, and without prejudice to appropriate agreements concluded or to be concluded among the launching States on jurisdiction and control over the space object and over any personnel thereof.

3. The contents of each registry and the conditions under which it is maintained shall be determined by the State of registry concerned.

Article III

1. The Secretary-General of the United Nations shall maintain a Register in which the information furnished in accordance with article IV shall be recorded.

2. There shall be full and open access to the information in this Register.

Article IV

1. Each State of registry shall furnish to the Secretary-General of the United Nations, as soon as practicable, the following information concerning each space object carried on its registry:

(a) Name of launching State or States;

(b) An appropriate designator of the space object or its registration number;

(c) Date and territory or location of launch;

(d) Basic orbital parameters, including:

(i) Nodal period,

(ii) Inclination,

(iii) Apogee,

(iv) Perigee;

(e) General function of the space object.

2. Each State of registry may, from time to time, provide the Secretary-General of the United Nations with additional information concerning a space object carried on its registry.

3. Each State of registry shall notify the Secretary-General of the United Nations, to the greatest extent feasible and as soon as practicable, of space objects concerning which it has previously transmitted information, and which have been but no longer are in earth orbit.

Article V

Whenever a space object launched into earth orbit or beyond is marked with the designator or registration number referred to in article IV, paragraph 1 (b), or

both, the State of registry shall notify the Secretary-General of this fact when submitting the information regarding the space object in accordance with article IV. In such case, the Secretary-General of the United Nations shall record this notification in the Register.

Article VI

Where the application of the provisions of this Convention has not enabled a State Party to identify a space object which has caused damage to it or to any of its natural or juridical persons, or which may be of a hazardous or deleterious nature, other States Parties, including in particular States possessing space monitoring and tracking facilities, shall respond to the greatest extent feasible to a request by that State Party, or transmitted through the Secretary-General on its behalf, for assistance under equitable and reasonable conditions in the identification of the object. A State Party making such a request shall, to the greatest extent feasible, submit information as to the time, nature and circumstances of the events giving rise to the request. Arrangements under which such assistance shall be rendered shall be the subject of agreement between the parties concerned.

Article VII

1. In this Convention, with the exception of articles VIII to XII inclusive, references to States shall be deemed to apply to any international intergovernmental organization which conducts space activities if the organization declares its acceptance of the rights and obligations provided for in this Convention and if a majority of the States members of the organization are States Parties to this Convention and to the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.

2. States members of any such organization which are States Parties to this Convention shall take all appropriate steps to ensure that the organization makes a declaration in accordance with paragraph 1 of this article.

Article VIII

1. This Convention shall be open for signature by all States at United Nations Headquarters in New York. Any State which does not sign this Convention before its entry into force in accordance with paragraph 3 of this article may accede to it at any time.

2. This Convention shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Secretary-General of the United Nations.

3. This Convention shall enter into force among the States which have deposited instruments of ratification on the deposit of the fifth such instrument with the Secretary-General of the United Nations.

4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of the Convention, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Secretary-General shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification of and accession to this Convention, the date of its entry into force and other notices.

Article IX

Any State Party to this Convention may propose amendments to the Convention. Amendments shall enter into force for each State Party to the Convention accepting the amendments upon their acceptance by a majority of the States Parties to the Convention and thereafter for each remaining State Party to the Convention on the date of acceptance by it.

Article X

Ten years after the entry into force of this Convention, the question of the review of the Convention shall be included in the provisional agenda of the United Nations General Assembly in order to consider, in the light of past application of the Convention, whether it requires revision. However, at any time after the Convention has been in force for five years, at the request of one third of the States Parties to the Convention and with the concurrence of the majority of the States Parties, a conference of the States Parties shall be convened to review this Convention. Such review shall take into account in particular any relevant technological developments, including those relating to the identification of space objects.

Article XI

Any State Party to this Convention may give notice of its withdrawal from the Convention one year after its entry into force by written notification to the Secretary-General of the United Nations. Such withdrawal shall take effect one year from the date of receipt of this notification.

Article XII

The original of this Convention, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United States, who shall send certified copies thereof to all signatory and acceding States.

APPENDIX F. THE 1972 ANTI-BALLISTIC TREATY (ABM TREATY), AGREED INTERPRETATIONS AND UNILATERAL STATEMENTS REGARDING THE ABM TREATY

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Proceeding from the premise that nuclear war would have devastating consequences for all mankind,

Considering that effective measures to limit anti–ballistic missile systems would be a substantial factor in curbing the race in strategic offensive arms and would lead to a decrease in the risk of outbreak of war involving nuclear weapons,

Proceeding from the premise that the limitation of anti–ballistic missile systems, as well as certain agreed measures with respect to the limitation of strategic offensive arms, would contribute to the creation of more favorable conditions for further negotiations on limiting strategic arms,

Mindful of their obligations under Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons,

Declaring their intention to achieve at the earliest possible date the cessation of the nuclear arms race and to take effective measures toward reductions in strategic arms, nuclear disarmament, and general and complete disarmament,

Desiring to contribute to the relaxation of international tension and the strengthening of trust between States,

Have agreed as follows:

ARTICLE I

1. Each Party undertakes to limit anti–ballistic missile (ABM) systems and to adopt other measures in accordance with the provisions of the Treaty.

2. Each Party undertakes not to deploy ABM systems for a defense of the territory of its country and not to provide a base for such a defense, and not to deploy ABM systems for defense of an individual region except as provided for in Article III of this Treaty.

ARTICLE II

1. For the purpose of this Treaty an ABM system is a system to counter strategic ballistic missiles or their elements in flight trajectory, currently consisting of:

(a) ABM interceptor missiles, which are interceptor missiles constructed and deployed for an ABM role, or of a type tested in an ABM mode;

(b) ABM launchers, which are launchers constructed and deployed for launching ABM interceptor missiles; and

(c) ABM radars, which are radars constructed and deployed for an ABM role, or of a type tested in an ABM mode.

2. The ABM system components listed in paragraph 1 of this Article include those which are:

(a) operational;
(b) under construction;
(c) undergoing testing;
(d) undergoing overhaul, repair or conversion; or
(e) mothballed.

ARTICLE III

Each Party undertakes not to deploy ABM systems or their components except that:

(a) within one ABM systems deployment area having a radius of one hundred and fifty kilometers and centered on the Party's national capital, a Party may deploy: (1) no more than one hundred ABM launchers and no more than one hundred ABM interceptor missiles at launch sites, and (2) ABM radars within no more than six ABM radar complexes, the area of each complex being circular and having a diameter of no more than three kilometers; and

(b) within one ABM system deployment area having a radius of one hundred and fifty kilometers and containing ICBM silo launchers, a Party may deploy: (1) no more than one hundred ABM radars and no more than one hundred ABM interceptors at launch sites, (2) two large phased-array ABM radars comparable in potential to corresponding ABM radars operational or under construction on the date of signature of the Treaty in an ABM system deployment area containing ICBM silo launchers, and (3) no more than eighteen ABM radars each having a potential less than the potential of the smaller of the above-mentioned two large phased-array radars.

ARTICLE IV

The limitations provided for in Article III shall not apply to ABM systems or their components used for development or testing, and located within current or additionally agreed test ranges. Each Party may have no more than a total of fifteen ABM launchers at test ranges.

ARTICLE V

1. Each Party undertakes not to develop, test, or deploy ABM systems or components which are sea-based, air-based, space-based, or mobile land-based.

2. Each Party undertakes not to develop, test, or deploy ABM launchers for launching more than one ABM interceptor missile at a time from each launcher, nor to modify deployed launchers to provide them with such a capability, nor to test, or deploy automatic or semi-automatic or other similar systems for rapid reload of ABM launchers.

ARTICLE VI

To enhance assurance of the effectiveness of the limitations on ABM systems and their components provided by this Treaty, each Party undertakes:

(a) not to give missiles, launchers, or radars, other than ABM interceptor missiles, ABM launchers, or ABM radars, capabilities to counter strategic ballistic missiles or their elements in flight trajectory, and not to test them in an ABM mode; and

(b) not to deploy in the future radars for early warning of strategic ballistic missile attack except at locations along the periphery of its national territory and oriented outward.

ARTICLE VII

Subject to the provisions of this treaty, modernization and replacement of ABM systems or their components may be carried out.

ARTICLE VIII

ABM systems or their components in excess of the numbers or outside the areas specified in the Treaty, as well as ABM systems or their components prohibited by this Treaty, shall be destroyed or dismantled under agreed procedures within the shortest possible agreed period of time.

ARTICLE IX

To assure the viability and effectiveness of the Treaty, each Party undertakes not to transfer to other States, and not to deploy outside national territory, ABM systems or their components limited by this Treaty.

ARTICLE X

Each Party undertakes not to assume any international obligation which would conflict with this Treaty.

ARTICLE XI

The Parties undertake to continue active negotiations for limitations on strategic offensive arms.

ARTICLE XII

1. For the purpose of providing assurance of compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.

2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with Paragraph 1 of the Article.

3. Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Treaty. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.

ARTICLE XIII

1. To promote the objectives and implementation of the provisions of this Treaty, the Parties shall establish promptly a Standing Consultative Commission, within the framework of which they will:

(a) consider questions concerning compliance with the obligations assumed and related situations which may be considered ambiguous;

(b) provide on a voluntary basis such information as either Party considers necessary to assure confidence in compliance with the obligations assumed;

(c) consider questions involving unintended interference with national technical means of verification;

(d) consider possible changes in the strategic situation which have a bearing on the provisions of the Treaty;

(e) agree upon procedures and dates for destruction or dismantling of ABM systems or their components in cases provided for by the provisions of this treaty;

(f) consider, as appropriate, possible proposals for further increasing the viability of this Treaty, including proposals for amendments in accordance with the provisions of the Treaty;

(g) consider, as appropriate, proposals for further measures aimed at limiting strategic arms.

2. The Parties through consultation shall establish and may amend as appropriate, Regulations for the Standing Consultative Commission governing procedures, composition and other relevant matters.

ARTICLE XIV

1. Each Party may propose amendments to this Treaty. Agreed amendments shall enter into force in accordance with the procedures governing the entry into force of this Treaty.

2. Five years after entry into force of this Treaty, and at five-year intervals thereafter, the Parties shall together conduct a review of the Treaty.

ARTICLE XV

1. This Treaty shall be of unlimited duration.

2. Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary event related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party prior to

withdrawal from the Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.

ARTICLE XVI

1. This Treaty shall be subject to ratification in accordance with the constitutional procedures of each Party. The Treaty shall enter into force on the day of the exchange of instruments of ratification.

2. This Treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

1. *Agreed Statements*

The document set forth below was agreed upon and initialed by the Heads of the Delegations on May 26, 1972:

[A]

The Parties understand that, in addition to the ABM radars which may be deployed in accordance with subparagraph (a) of Article III of the Treaty, those non-phased-array ABM radars operational on the date of signature of the Treaty within the ABM system deployment area for defense of the national capital may be retained.

[B]

The Parties understand that the potential (the product of mean emitted power in watts and antenna area in square meters) of the smaller of the two large phased-array ABM radars referred to in subparagraph (b) of Article III of the Treaty is considered for purposes of the Treaty to be three million.

[C]

The Parties understand that the center of the ABM system deployment area centered on the national capital and the center of the ABM

system deployment area containing ICBM silo launchers for each Party shall be separated by no less than thirteen hundred kilometers.

[D]

In order to ensure fulfillment of the obligation not to deploy ABM systems and their components except as provided in Article III of the Treaty, the Parties agree that in the event ABM systems based on other physical principles and including components capable of substituting for ABM interceptors missiles, ABM launchers, or ABM radars are created in the future, specific limitations on such systems and their components would be subject to discussion in accordance with Article XIII and agreement in accordance with Article XIV of the Treaty.

[E]

The Parties understand that Article V of the Treaty includes obligations not to develop, test, or deploy ABM interceptor missile for the delivery by each ABM interceptor missile of more than one independently guided warhead.

[F]

The Parties agree not to deploy phased-array radars having a potential (the product of mean emitted power in watts and antenna area in square meters) exceeding three million, except as provided for in Article III, IV and VI of the Treaty, or except for the purposes of tracking objects in outer space or for use as national technical means of verification.

[G]

The Parties understand that Article IX of the Treaty includes the obligation of the US and the USSR not to provide to other States technical descriptions or blue prints specially worked out for the construction of ABM systems and their components limited by the Treaty.

2. *Common Understandings*

Common understanding of the Parties on the following matter was reached during the negotiations:

A. Location of ICBM Defenses

The US Delegation made the following statement on May 26, 1972:

Article III of the ABM Treaty provides for each side on ABM system deployment area centered on its national capital and one ABM system deployment area containing ICBM silo launchers. The two sides have

registered agreement on the following statement: "The Parties understand that the center of the ABM system deployment area centered on the national capital and the center of the ABM system deployment area containing ICBM silo launchers for each Party shall be separated by no less than thirteen hundred kilometers." In this connection, the US side notes that its ABM system deployment area for defense of ICBM silo launchers, located west of the Mississippi River, will be centered in the Grand Forks ICBM silo launcher deployment area. (See Initialed Statement [C].)

B. ABM Test Ranges

The US Delegation made the following statement on April 26, 1972:

Article IV of the ABM Treaty provides that "the limitations provided for in Article III shall not apply to ABM systems or their components used for development of testing, and located within current or additionally agreed test ranges." We believe it would be useful to assure that there is no misunderstanding as to current ABM test ranges. It is our understanding that ABM test ranges encompass the area within which ABM components are located for test purposes. The current US ABM test ranges are at White Sands, New Mexico, and at Kwajalein Atoll, and the current Soviet ABM test range is near Sary Shagan in Kazakhstan. We consider that non-phased array radars of types used for range safety or instrumentation purposes may be located outside of ABM test ranges. We interpret the reference in Article IV to "additionally agreed test ranges" to mean that ABM components will not be located at any other test ranges without prior agreement between our Governments that there will be such additional ABM test ranges.

On May 5, 1972, the Soviet Delegation stated that there was a common understanding on what ABM test ranges were, that the use of the types of non-ABM radars for range safety or instrumentation was not limited under the Treaty, that the reference in Article IV to "additionally agreed" test ranges was sufficiently clear, and that national means permitted identifying current test ranges.

C. Mobile ABM Systems

On January 28, 1972, the US Delegation made the following statement:

Article V (I) of the Joint Draft Text of the ABM Treaty includes an undertaking not to develop, test, or deploy mobile land-based ABM systems and their components. On May 5, 1971, the US side indicated that,

in its view, a prohibition on deployment of mobile ABM systems and their components would rule out the deployment of ABM launchers and radars which were not permanent fixed types. At that time, we asked for the Soviet view of this interpretation. Does the Soviet side agree with the US side's interpretation put forward on May 5, 1971?

On April 13, 1972, the Soviet Delegation said there is a general common understanding of this matter.

D. Standing Consultative Commission

Ambassador Smith made the following statement on May 22, 1972:

The United States proposes that the sides agree that, with regard to initial implementation of the ABM Treaty's Article XIII on the Standing Consultative Commission (SCC) and of the consultation Articles to the Accidents Agreement, agreement establishing the SCC will be worked out early in the follow-on SALT negotiations; until that is completed, the following arrangements will prevail: when SALT is in session, any consultation desired by either side under these Articles be carried out by the two SALT Delegations; when SALT is not in session, *ad hoc* arrangements for any desired consultations under these Articles may be made through diplomatic channels.

Minister Semenov replied that, on an *ad referendum* basis, he could agree that the US statement corresponded to the Soviet understanding.

E. Standstill

On May 6, 1972, Minister Semenov made the following statement:

In an effort to accommodate the wishes of the US side, the Soviet Delegation is prepared to proceed on the basis that the two sides will in fact observe the obligations of both the Interim Agreement and the ABM Treaty beginning from the date of signature of these two documents.

In reply, the US Delegation made the following statement on May 20, 1972:

The US agree in principle with the Soviet statement made on May 6 concerning observance of obligations beginning from date of signature but we would like to make clear our understanding that this means that, pending ratification and acceptance, neither side would take any action prohibited by the agreements after they had entered into force. This un-

derstanding would continue to apply in the absence of notification by either signatory of its intention not to proceed with ratification or approval.

The Soviet Delegation indicated agreement with the US statement.

3. *Unilateral Statements*

The following noteworthy unilateral statements were made during the negotiations by the United States Delegation:

A. Withdrawal from the ABM Treaty

On May 9, 1972, Ambassador Smith made the following statement:

The US Delegation has stressed the importance of the US Government attaches to achieving agreement on more complete limitations on strategic offensive arms, following agreement on an ABM Treaty and on an Interim Agreement on certain measure with respect to the limitations of strategic offensive arms. The US Delegation believes that an objective of the follow-on negotiations should be to constrain and reduce on a long-term basis threats to the survivability of our respective strategic retaliatory forces. The USSR Delegation has also indicated that the objectives of SALT would remain unfulfilled without the achievement of an agreement providing for more complete limitations on strategic offensive arms. Both sides recognize that the initial agreements would be steps toward the achievement of more complete limitations on strategic arms. If an agreement providing for more complete strategic offensive arms limitations were not achieved within five years, US supreme interest could be jeopardized. Should that occur, it would constitute a basis for withdrawal from the ABM Treaty. The US does not wish to see such a situation occur, nor do we believe that the USSR does. It is because we wish to prevent such a situation that we emphasize the importance that the US Government attaches to achievement of more complete limitations on strategic offensive arms. The US Executive will inform the Congress, in connection with Congressional consideration of the ABM Treaty and the Interim Agreement, of this statement of the US position.

B. Tested in ABM Mode

On April 7, 1972, the US Delegation made the following statement:

Article II of the Joint Text Draft uses the term "tested in an ABM mode," in defining ABM components, and Article VI includes certain obligations concerning such testing. We believe that the sides should have

a common understanding of this phrase. First, we would note that the testing provisions of the ABM Treaty are intended to apply to testing which occurs after the date of signature of the Treaty, and not to any testing which may have occurred in the past. Next, we would amplify the remarks we have made on this subject during the previous Helsinki phase by setting forth the objectives which govern the US view on the subject, namely, while prohibiting testing of non-ABM components for ABM purposes: not to prevent testing of ABM components, and not to prevent testing of non-ABM components for non-ABM purposes. To clarify our interpretation of "tested in an ABM mode," we note that we would consider a launcher, missile or radar to be "tested in an ABM mode" if, for example, any of the following events occur: (1) a launcher is used to launch an ABM interceptor missile, (2) an interceptor missile is flight tested against a target vehicle which has a flight trajectory with characteristics of a strategic ballistic missile flight trajectory or an ABM interceptor missile or an ABM radar at the same test range, or is flight tested to an altitude inconsistent with interception of targets against which air defenses are deployed, (3) a radar makes measurements on a cooperative target vehicle of the kind referred to in item (2) above during the reentry portion of its trajectory or makes measurements in conjunction with the test of an ABM interceptor missile or an ABM radar at the same test range. Radars used for purposes such as range safety or instrumentation would be exempt from application of the criteria.

C. No-Transfer Article of ABM Treaty

On April 18, 1972, the US Delegation made the following statement:

> In regard to this Article [IX], I have a brief and I believe self-explanatory statement to make. The US side wishes to make clear that the provisions of this Article do not set a precedent for whatever provision may be considered for a Treaty on Limiting Strategic Offensive Arms. The question of transfer of strategic offensive arms is a far more complex issue, which may require a different solution.

D. No Increase in Defense of Early Warning Radars

On July 28, 1970, the US Delegation made the following statement:

> Since Hen House radars [Soviet ballistic-missile early-warning radars] can detect and track ballistic missile warheads at great distances, they have a significant ABM potential. Accordingly, the US would regard any increase in the defenses of such radars by surface-to-air missiles as inconsistent with an agreement.

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